Historyonics Pest Management Guide

Pest management in collection storage

Pest management in storage facilities should not be simply a reaction to the discovery of insect activity and damage. Every facility should reduce the risk of damage by adopting a programme that includes monitoring for pests, targeting treatment only where it is needed and modifying the environment to discourage pest attack.

The following document aims to address the most important factors which should be considered in forming a policy to manage a collection in storage.

These factors are:

1. **An understanding of IPM**
2. **Sources of infestation in a building or collection**
3. **Detection, inspection and monitoring methods**
4. **Management through prevention of access**
5. **Treatment options**
6. **Alternative treatment options**
7. **A knowledge of the main insect pests and their basic biology**
8. **Risk Zones as part of an IPM Strategy**

1 An understanding of IPM

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment. The IPM approach can be applied to any setting where pests are a problem.

1.1 How do IPM programs work?

IPM is not a single pest control method but, rather, a series of pest management evaluations, decisions and controls. In practicing IPM, to avoid the potential for a pest infestation follow a four-tiered approach. The four steps include:

1.2 Set Action Thresholds

Before taking any pest control action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken. Sighting a single pest does not always mean control is needed. The level at which pests will become an economic threat is critical to guide future pest control decisions.

1.3 Monitor and Identify Pests

Not all insects and other living organisms require control. Many individuals that can be found in stores are innocuous, and some are even beneficial. IPM programs work to monitor for pests and identify them accurately, so that appropriate control decisions can be made in conjunction with action thresholds. This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used.

1.4 Prevention

As a first line of pest control, IPM programs work to manage the indoor space to prevent pests from becoming a threat. In an storage situation, this may mean using cultural methods, such as rotating and moving stock, not filling the store too densely, maintaining good hygiene. These preventative control methods can be very effective and cost-efficient and present little to no risk to people or the environment.

1.5 Control

Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper control method both for effectiveness and risk. Effective, less risky pest controls are chosen first such as increased housekeeping. If further monitoring, identifications and action thresholds indicate that these are not working, then additional pest control methods would be employed, such as targeted application of insecticides.

2 Sources of infestation in a building or collection

Insects are mobile and, given the right conditions, can spread and move rapidly into uninfested areas. The most common methods of introducing infestation are:

- introduction into collections of new material infested at a low level, which is undetected. The infestation may be on new acquisitions or on material on loan from another institution. Material which was sent out on loan may return with infestation acquired while it was away.
- spread of infestation from another source in the facility, such as voids, ventilation channels etc.
- introduction of insects from outside, *via* windows and doors.

The importance and relevance of these routes depends upon the type of pest and material at risk. Specific examples include the spread of carpet beetle larvae from old pigeon nests in roof areas and adult female carpet beetle or furniture beetle flying through open windows and laying eggs on objects.

For materials to be at risk, they must be stored under conditions which favour insect development. Food is not likely to be a limiting factor in most collection stores as a wide variety of wool, skins, fur, and feathers will support carpet beetle and clothes moths and many woods will be attacked by furniture beetle. Dead insects such as flies will provide food for carpet beetles and spider beetles.

Temperatures over 20°C will encourage rapid development of infestation and temperatures should be kept at 10-15°C to slow down development of most species. Extremely low temperatures (<-20°C) may be required for protracted periods to kill infestation. Although high humidity will encourage some insects such as furniture beetle and silverfish, many of the major pest species can tolerate conditions of 60% RH or less. Therefore, humidity control on its own, whilst beneficial, will not control pest problems. It is important to recognise that localised areas of high humidity may give rise to mould problems which may in turn encourage some species of insect pests, including booklice, particularly if this is associated with low standards of cleanliness.

3 Detection, inspection and monitoring methods

The use of insect traps for monitoring is the priority in setting up an IPM programme in any location. Early warning of pest presence is vital to successful pest control strategies and damage prevention is of paramount importance. Unless areas can be guaranteed to be insect-free then efforts must be made to find any intruders at the earliest possible point.

Quarantine and pre-inspection are key. Careful visual examination of materials taken into storage areas or in preparation for display is essential. Isolate for observation, before moving items into the collection area. Although it can be extremely time-consuming, the importance of this practice cannot be over-emphasised. Once material is in store, it may not be examined again for a long period of time, even if it is vulnerable to pest attack. If it is not feasible or economic to inspect individual items frequently, then the store or display area should be regularly examined for insects or the presence of infestation signalled by cast skins, frass or dust. Good lighting is essential and in the gloomy conditions which frequently prevail in stores, it is vital to use a bright torch for inspection.

3.1 Insect monitoring

3.1.1 Insect traps

One way of supplementing visual inspection is to use insect traps. Sticky blunder traps designed to catch roving insects that may wander around storage facilities. These function by intercepting insects as they move around a building and so should be located at wall-floor junctions, where wall direction changes, in corners, and against vertical surfaces such as crates, pillars or pallets.

Museum Trap with glue on two internal faces

Plastic floor trap with removable glue card

These non-specific sticky traps should be used as basic monitoring devices for insects such as silverfish, booklice, ground beetles, carpet beetles and other crawling insects. Sticky blunder traps are good for monitoring the residual population of insects in a building to assess the risk to the collection. They can also give a useful indication of the number of crawling pests which are invading a room or building.

Traps should be placed in a regular grid pattern against wall floor angles, preferably in corners where they will catch more wandering insects. Plastic floor traps are low in height and can be tucked under shelves and storage units. Numbers should be matched to the priorities of the collection and a trapping programme should not exceed the resources available to check the traps.

3.1.2 Lures and attractants

Insect trap efficacy can be greatly increased using attractants and lures. These can be food or other attractive compounds (kairomone) baits, which are useful in attracting insects into sticky traps, or for many insects, especially beetles and moths, using sex attractant pheromones. These latter hormones are secreted by either male or more usually female insects. The synthesised sex pheromone of female clothes moths, carpet beetles and many food product pests have been found to be powerful lures. They can be very effective in reducing insect populations.

Carpet Beetle adult caught on Museum Trap with added pheromone lure for Varied Carpet Beetle

Carpet Beetle larva caught on detector with added general lure for dermestid beetles

Pheromone traps which contain a synthetic attractant lure for clothes moth can be very effective. The flight activity of the males is stimulated by the pheromone and suspended traps provide a very useful early warning of infestation. When temperatures are high enough to promote flight, up to 20 times as many moths may be caught on traps with pheromone lures as on unbaited ones. When temperatures are below 18°C, the males are reluctant to fly, and the suspended traps may be less effective. In these situations, the pheromone trap can be placed on the floor and the traps with lures will catch more male moths. Pheromone traps should be used in areas where there is a high risk to valuable objects or where a particular pest insect species is suspected. Pheromone lures are not available for all pests of collections.

3.2 General principles of insect trapping in storage facilities

- Survey the site and prepare a plan to decide where to place traps
- Traps should normally only be placed in areas where there are collections.
- Place sticky traps in a regular grid pattern with all traps date-labelled and their position marked on a plan.
- Place traps on floors in corners and near walls, not in the middle of open areas.
- Check traps at regular intervals. A suggested frequency of trap check is four times a year in March, June, September and December.
- Identify and record insects caught on traps. It is also useful to record whether the insects caught are larvae or adults.
- The more traps that are used, the greater the chance of finding insects but the workload should not be underestimated, and trapping programmes should be designed to be manageable.
- Pheromone lures and traps will catch far more insects than unbaited traps. This may cause panic initially. They are valuable for accurate monitoring and early warning in sensitive areas.
- Large numbers of non-pest insects may be caught on traps if they are near outside doors. When this happens, the traps should be replaced more frequently, or the trapped insects will become food for pests such as mice.
- Over a period of time, a record of catch will build up a picture of the distribution of insects. Additional traps should be placed in areas where pests need to be more accurately pinpointed.
- Traps should be used to supplement regular visual inspection of vulnerable objects and the information can be used to target preventative and remedial measures.
- Care should always be taken regarding the presence of bats. Insects trapped on glue traps can also attract bats and care should be taken in how traps are placed and presented.

4 Management through prevention of access

A tight, waterproof, smooth surface is easier to clean and keep clean. Where possible eliminate cracks and crevices in storage and handling areas as these can provide harbourages for pests. Cracks and crevices leading into voids often form insect breeding and harbourage areas.

Make all areas accessible to routine cleaning. Seal cabinets and other equipment to the wall or floor or have at least 15cm inches of clearance to allow adequate cleaning below and behind.

Containers should be stacked on pallets. Use plastic pallets where possible or ensure wooden pallets are treated to International Standards For Phytosanitary Measures No. 15 (ISPM 15).

Leave aisles between stacked containers and walls for inspection and cleaning. Where practical, stack items 45cm off the floor and 45cm away from walls.

Make sure that all doors and windows are tight fitting and that screens are provided on all windows and doors that can be opened. Screened doors should open to the outside.

If present, food handling and storage areas should be rodent proof and bird proof. Mice can enter openings less than 6-7mm, and rats can enter openings less than 12-13mm in diameter.

Remove waste food or garbage to proper storage or disposal sites at least daily.

Design a routine schedule for cleaning all areas. Some areas may need cleaning only once a week, others every day. In addition, spot clean spills and accidents.

Train maintenance personnel in sanitation and provide information on pest biology.

Prevent pest pressure from growing by preventing sites for birds and rodents to nest and removing nest material when practical and possible.

Externally, keep grass short, shrubs neatly trimmed and clean paved access ways. Maintain proper drainage to reduce or eliminate shelter areas for pests.

Place waste in enclosed containers that are emptied regularly. Containers should be off the ground on racks or on a concrete slab.

Locate outdoor lighting fixtures at a distance from buildings and aim them toward the buildings to help keep flying insects that are attracted to light away from doors and windows.

Poor hygiene results in localised areas of high food value, which are dark, and humid, especially if they remain undisturbed for long periods of time. A clean, cool, dry environment can do more to prevent and limit pest problems than many other measures.

Good housekeeping has a cost but poor hygiene costs more.

5 Treatment Options

At some point in the life of a storage environment, insecticide intervention is likely.

Which products are used depends on the pest to be tackled and the effect to be achieved. Insecticides can work by direct contact or by leaving a residual deposit so the treated article is protected from insect attack.

Two principal methods of application can be considered. The main difference in the application is the droplet sizes.

5.1 Surface treatments

Surface sprays use a large droplet size. This can be made direct from a ready to use product fitted with a trigger spray or the product can be decanted into a purpose sprayer. These are normally pumped to pressurise, and the insecticide applied to a surface through a lance fitted with an appropriate nozzle. Other surface treatments involve powders where the insecticide active is mixed with an inert carrier (such as for ant control).

Surface treatments are used to apply residual insecticides to kill insects in harbourages and dead spaces in fittings and buildings. Residual insecticides such as Constrain which contains cypermethrin, will have differing periods of activity which is determined by several factors such as permeability of the surface or article treated. The following will have a shortening effect on the working life of a residual deposit: exposure to UV and sunlight; foot traffic (for treated surfaces such as carpets); vacuuming, cleaning and washing of surfaces; accumulation of dirt and debris.

5.2 Space treatments

Use a small droplet size so the insecticide remains suspended in the air for a period of time. The spray can be applied by equipment using heat (hot fog) or mechanical processes (cold fog). Very small droplets are considered aerosol in size and these will remain suspended the longest and equipment can be directed at certain areas to penetrate cracks and crevices that are not easily reached from the ground. Aerosol cannisters are available that are known as total release such that they give off all their contents once activated. These are useful where no specialised application equipment is available. Other space treatments can be applied using smokes where a heat generates a chemical reaction and causes small smoke particles to penetrate a space.

Space treatments do not often leave a residual effect and so need to be applied more than once, or where an infestation may exist, on a weekly or fortnightly programme. Leaving a gap between applications allows insects that existed as larvae or pupae during the first treatment, to emerge as adults and be targeted by the subsequent.

Space treatments are useful in managing materials that are in quarantine.

6 Alternative treatment options

Only in recently years have studies looked at the efficiency of insecticides on collections pests and consideration given to the deleterious effect of some insecticides on collections and staff. As a result, a number of alternative treatments that do not rely on chemical insecticides have been developed. The following lists some of the treatment methods suitable for archival collections.

6.1 Temperature manipulation

Either cold or hot temperatures will kill all stages of insect life (egg, larva, pupa and adult). Temperatures below -25°C for 3 or more days or temperatures above 55°C for 1 or more hours will normally be effective. Freezing textiles at -18 °C for 2 weeks is normally required to kill all life stages including eggs of moths and beetles. It is necessary to keep the objects in a micro-environment to maintain stable relative humidity, e.g. by sealing in plastic, or by using a climate controlled cabinet as in some heating processes. The objects need to be left in their controlled environment after the treatment until they return to ambient temperature before being removed from the sealed bag.

6.2 Anoxic fumigation

Insects need oxygen to survive, so treatments which remove oxygen from their environment will kill them. Chambers with suitably humidified nitrogen gas are effective if sufficient time is allowed to kill the insects. At 25°C, two weeks is normally sufficient but at lower temperatures, longer treatment times are needed. Small scale anoxic treatments can be carried out using gas-tight bags and oxygen absorbing chemicals.

6.3 Conventional fumigation using toxic insecticidal gases

Until recently, the only satisfactory treatment for a large-scale insect infestation was to fumigate with toxic gases. Currently, only carbon dioxide and phosphine can be legally used in the UK. Both have reasonable penetration and efficacy in treating large quantities of material but can cause deleterious changes to some materials. Where possible, they should be replaced with less harmful alternatives.

Good design and maintenance of buildings, storage systems and storage containers that allow a high state of cleanliness and good housekeeping policies, combined with a regular monitoring and inspection programme, provides the best long-term strategy for insect pest prevention in collections. Pest control measures where necessary should be strategic, targeted and non-residual if possible.

6.4 Inert material deposits - diatomaceous earth

Silicium dioxide powder, otherwise known as diatomaceous earth (DE) or amorphous contains the fossilized remains of tiny, aquatic organisms called diatoms. Their skeletons are made of a natural substance called silica. This powder acts on the outer layer of the cuticle of any insect it contacts such that their outer, protective waxy coating is disrupted and the insect dies. As there is no chemical component, the residual effect is very long (Months and years) provided enough of a deposit is applied. Aerosol forms are available to blast DE powder into cracks and crevices. It provides an alternative to residual insecticides where these are to be avoided.

7 A knowledge of the main insect pests and their basic biology.

The major insect pests can be categorised according to the food source which they require for their development; for example, wood-boring beetle, clothes moth and carpet beetle. The following illustrates examples of some of the major insect pests that may be encountered in stores.

Insects develop through a series of stages depending on whether they follow complete or incomplete metamorphosis. Three phases comprise incomplete metamorphosis: egg, nymph, and adult. The four phases of complete metamorphosis are egg, larva, pupa, and adult. Incomplete metamorphosis permits some of the insect's exoskeleton to persist throughout its life cycle.

7.1 Complete

Eggs are laid on the foodstuff and because of their small size, they are rarely seen.
Larvae, emerge from eggs and then eat to grow. It is this stage that causes the damage to material. Owing to their small size and secretive habits they are also rarely seen until the damage caused by the eating becomes obvious.
Pupae are formed when larvae are fully grown, develops into a from which the last stage emerges.
Adults are the last fully formed stage that are sexually mature and often the most mobile. It is the adult that flies to find a mate and lay eggs and is usually the stage seen and caught in traps.e.g. beetles and moths.

7.2 Incomplete

Nymphs emerge from an egg and then go through several stages with each nymphal stage looking like a small version of the adult but getting slightly bigger with age. At the final nymphal stage the insect then moults into the adult form. e.g. booklice.

The exception to the above rules are silverfish which undergo simple or ametabolous metamorphosis as the nymph stage is a smaller version of the adult.

In temperate climates, the adults are normally active in early to mid-summer and eggs are laid at the end of the summer. In cold winters the insects may become dormant until warmer weather resumes their activity, so larval damage is most active in the autumn and spring periods. In warmer climates and centrally heated buildings, larval activity can continue throughout the year and insects such as clothes moth, with a normal one year life cycle, may have two or even three cycles if warmth and food permit.

7.3 Pests of cellulosic material

Cellulose is the principle constituent of wood, vegetable materials and associated products such as paper, cardboard, cotton and linen. A number of insect pests are associated with these materials.

7.3.1 Wood-borers

Anobium punctatum - common furniture beetle ('woodworm'). This is the predominant wood-borer in the UK, attacking wooden museum artefacts and is common throughout the world. Furniture beetle attacks seasoned softwoods and hardwoods, (usually only the sapwood areas,) but tropical hardwoods are immune from attack. Animal glue bonded plywoods, wickerwork and wood with some fungal decay are particularly susceptible to attack.

Anobium punctatum - adult beetle top view

Anobium punctatum - adult beetle side view

Infestation is initiated by adult beetles which fly in from outside, or from other infested material, and lay eggs on irregularities or in cracks on wooden surfaces. After 4-5 weeks, in early summer, the eggs hatch and each larva bores into the wood tunnelling through it for three or more years before pupating just under the surface of the wood. The adult beetle emerges through a small flight hole (the so-called woodworm holes) in early summer. The adults often lay eggs in the redundant flight hole before flying or crawling off to lay in other sites. Relatively few eggs are laid and although *Anobium* infestations may appear to build up relatively slowly, considerable damage may occur before an infestation is noticed.

7.3.2 Biscuit beetle

The larvae of ***Stegobium paniceum* -** biscuit beetle or drug store beetle are major pests of dried vegetable material such as herbarium specimens and will also attack paper products with a high starch content such as starch paste repairs. The larvae may damage hard materials such as leather bindings to pupate in them.

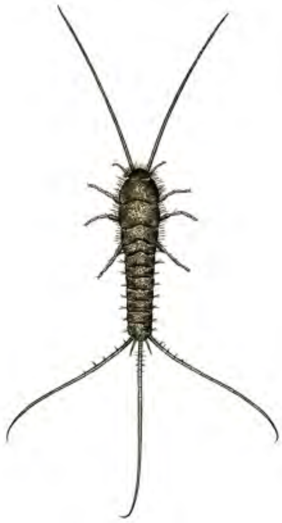
Stegobium paniceum - adult beetle top view

Stegobium paniceum - adult beetle side view

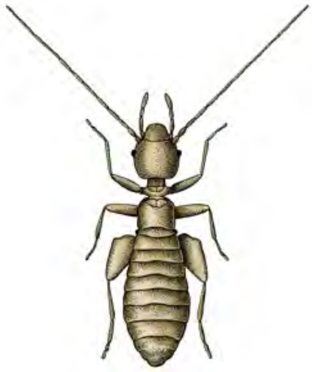
7.3.3 Paper pests

Lepisma saccharina- silverfish.
Liposcelis bostrychophylus and ***Lepinotus patruelis*** - psocids or booklice.
Though usually associated with highly-humid situations, both types of pests are adaptable to other conditions. Silverfish tend to cause damage by feeding on the surface of cellulosic materials, while psocids tend to feed on the surface of paper or packaging which has been contaminated or attacked by microscopic moulds.

14 *Lepisma saccharina* - Silverfish adult



Ctenolepisma longicaudata - Grey silverfish adult



Liposcelis bostrychophilla - Book lice adult

7.4 Pests of keratinous material

Keratin is the structural protein found in hair, wool, parchment, feather, horn, nail and hoof, and is especially vulnerable to attack by insect pests when soiled or contaminated. It forms the main diet of a number of insect pests, particularly certain moths and beetles.

7.4.1 Clothes moths and house moths

***Tineola bisselliella* -** common (webbing) clothes moth.
***Tinea pellionella* -** case-bearing clothes moth
***Hofmannophila pseudospretella* -** brown house moth
***Endrosis sarcitrella* -** white-shouldered house moth

The above four moth species are found throughout the world and are pests of textile, ethnographic and natural history collections. The larval stages feed mainly on keratinous material which they destroy and despoil with silk webbing and frass deposits of debris and faecal pellets. Damage commonly appears as ragged, irregular patches or holes. The webbing clothes moth is now a very common pest in the UK.

Tineola bisselliella - Webbing clothes moth adult

Tineola bisselliella - Webbing clothes moth larva

Tinea pellionella - Casemaking clothes moth adult

Tinea pellionella - Casemaking clothes moth larva

The adult moths are small narrow-winged insects with a variety of colouring from pale gold to mottled brown. They generally lay eggs in summer on a suitable substrate, and the emerging larvae feed on adjacent material, often inside a silken tube. Pupation occurs inside a tough silken cocoon. The length of the life cycle of the moth depends upon temperature conditions but may be up to a year for house moths or as few as eight to nine months for clothes moth.

7.4.2 Dermestid beetles

Anthrenus verbascii (Varied carpet beetle)
Anthrenus sarnicus (Guernsey carpet beetle)
Anthrenus fuscus (Dark or Small carpet beetle)
Attagenus pellio (Two-spot carpet beetle)
Dermestes lardarius (Larder Beetle)

Anthrenus verbascii (the varied carpet beetle) adult

Anthrenus verbascii (the varied carpet beetle) larva (woolly bear)

Attagenus pellio - Two-Spot Carpet Beetle or Fur Beetle adult

Attagenus pellio - Two-Spot Carpet Beetle or Fur Beetle larva.

Dermestes lardarius - Larder Beetle Adult

Dermestes lardarius - Larder Beetle larva

The principal insect pests of many collections are the larvae of certain beetles. Among these are a group known as Dermestid Beetles or Dermestidae which includes the larder beetle, hide or leather beetles, carpet beetles, and khapra beetles. These species are wide ranging in their habits consuming wool, fur, felt, silk, feathers, skins, nails, beaks and horn, all of which contain the protein keratin.

The larvae of *Anthrenus* and *Attagenus* beetles cause immense damage to dried insect collections and are major pests of wool, fur, feathers, leather and skins. The damage normally appears as clean, irregular holes which, in textiles, are often concentrated along seams etc. Infested natural history and ethnographic specimens commonly exhibit hair loss, and disintegration of feathers. Materials glued with animal glues are also commonly attacked.

The adult beetles feed and mate outside on pollen from flowers (particularly from Spireas and Umbelliferae) and come indoors in late summer to lay their eggs on a suitable undisturbed food source - under carpets, in bird's nests, fluff between floor boards etc. After hatching, the larvae feed voraciously and moult several times. After a period in pupation, the emerging adults appear in early summer and although they prefer to return to the outside to feed and mate, they can maintain and continue an infestation in enclosed cabinets or drawers.

7.5 Scavenging pests

7.5.1 *Ptinus tectus* - spider beetles.

The Australian spider beetle - *Ptinus tectus* is a pest increasing in frequency in the UK. The larvae feed on a range of vegetable and animal based materials, and bore into hard materials to pupate. The adult beetles often develop in birds' nests and roam widely.

Ptinus tectus - Australian spider beetle adult

Niptus hololeucus - Golden spider beetle adult

7.6 Nuisance pests

A number of insects can be a nuisance within buildings, but do not directly cause damage to objects. The most common nuisance insect pests are flies.

7.6.1 Domestic flies

This includes the house fly (*Musca domestica*) and the bluebottle (*Calliphora sp*) which are associated with poor hygiene and rotting organic matter, as that it where the eggs are laid the larvae develop and on which the adults emerge and feed.

7.6.2 Cluster flies

Includes several species of flies that congregate in large numbers inside buildings in the autumn to hibernate. Eggs are laid outside in fields, in animal dung etc., and the emerging larvae seek out and develop inside earthworms. The adults emerge in the summer and feed on the nectar and in late summer cluster on warm south-facing walls. The flies can push through the smallest gap to find dark, quiet places indoors to hibernate for the winter.

Pollenia rudis – Cluster Fly

7.6.3 Cockroaches

The species normally found in UK situations are either the German Cockroach *Blattella germanica* or the Oriental Cockroach *Blatta orientalis*. They are omnivorous and gregarious and can cause spoiling of objects with their droppings.

8 Risk Zones as part of an IPM Strategy

Integrated Pest Management (IPM) is a process which uses a range of approaches to manage pests and that relies on chemical treatment as a last option. IPM strategies are never fixed should be based on individual site conditions and respond to changing needs and priorities. Implementing an IPM programme in a store can be a daunting task. It is therefore important to identify priorities and plan to cover the collection in achievable steps.

Risk zones can enable all users of any space to be aware of risks and obligations especially when sharing a space and ensure focus action, such as housekeeping and monitoring on key targets.

The risk zone concept recognises that buildings will have a resident insect pest population and pest prevention should be commensurate with the determined level of risk. It is an effective method of dividing a large building into manageable sections and targeting IPM measures at the appropriate level.

Key aspects of the system include:

- Recognising that most buildings and historic houses are always likely to have a resident population of pest insects.
- Evaluation of the vulnerability of the collections or objects to insect attack.
- Assessment of the risk of collections being attacked by pests.
- Assignment of each area in the building to one of three risk zones.
    - High (red)
    - Medium (yellow)
    - Low (green)
- Determination of appropriate protocols for monitoring and trapping, inspection, and cleaning for each zone.

8.1 Risk Mapping and Collection Vulnerability

Assessment of the vulnerability of the collections contained within the building in combination with baseline level of each species of insect pests within, will determine how risk zones are assigned across the building structure, establishing areas that are at high, through to low risk of insect pest attack. A parallel system may be needed for assessing risk from rodent infestation as the parameters are very different from insects. Rodent presence can lead to insects as a secondary problem.

The level of risk to collections should be identified and each area assigned a colour code, based on a traffic light system. This can be indicated on building floor plans for ease of communication. The colour coding system relates to the level of risk to collections posed by insect pests, with red being the highest risk of damage, followed by yellow as moderate risk of damage, and green for areas that pose the least risk of damage. The three-tier traffic light system is recommended as it is universally recognised, easily understood and straightforward to implement and interpret.

The parameters for collection vulnerability to insect pest attack will depend on the organisation, building and collections held. The strategy must encompass all areas of the building, not just collections in storage or on display which may be more vulnerable to attack and should be prioritised to minimise damage to high-risk collections in a cost-effective way. Collection vulnerability to insect pest attack is determined by the type of collection material, whether it is on display, or in storage and the frequency of inspection.

Organic collections most likely be classified as at high risk include skins, feathers, textiles, wool, taxidermy, dried plant material and ethnography. Examples of collections at moderate risk include books, paper, wood etc. Collections not at risk from pest attack include metalwork, stone, ceramics, glass etc.

Other considerations that may influence the level of risk include; activities that take place, contents of cupboards in storage areas, doors, corridors and access routes, space adjacencies, potential zone boundaries and areas with shared ownership and responsibility.

The key to the successful implementation of an IPM strategy based on risk zones is organisation-wide collaboration and staff training and awareness. Staff involvement in risk zone designation, will result in increased buy-in and co-operation and the concept will more likely be realised and embedded in daily work practice. In parallel, a programme of staff training is necessary to ensure staff at all levels are aware of the requirements of operating within each zone. Signage will need to be developed to alert staff to the risk zone they are in and to raise visibility of the concept.

An IPM strategy based on risk zones is a flexible concept that can be adapted in response to the changing priorities of the organisation and new emerging pest threats. When used in combination with other IPM measures, such as quarantine, inspection and monitoring and trapping, the risk zoning concept is a useful and cost-effective tool on which to base an organisational PM strategy, mitigating against the risk of insect pest attack.