

MUSEUMS LIBRARIES ARCHIVES

Integrated pest management

A guide for museums, libraries and archives

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Introduction

All too often, pest control in museums is a reaction to the discovery of evidence of pest activity, such as damage to objects or elements of the building. The aim of this booklet is to provide practical, safe and cost-effective advice on the prevention and control of pests. It will explain what a museum needs to do to protect its collections, furnishings and buildings from harm by pests. It will describe some of the options for controlling infestations should they occur but concentrates on the strategies that will reduce the risks.

What is integrated pest management?

Integrated pest management (IPM) is a term originally adopted to describe the development of pest control methods for fruit and cereal crops that do not rely on the regular and systematic use of pesticides. The approach is one of using non-invasive methods to prevent or at least minimise the risk of pest infestation. The main principles of IPM - monitoring, discouraging pests, modifying the environment and targeting treatments - have been adapted for use with heritage and cultural collections. The approach has considerable advantages regarding health and safety, being less harmful to both humans and the environment, and once established is also likely to be more cost effective than a passive or reactive approach.

Why IPM in a museum, library or archive?

The care of collections and historic buildings involves many different disciplines, including conservation and management of both collections and buildings. The major factors causing deterioration are the environmental effects of light, humidity and temperature, and agents of decay such as insects, mould and rodents. All of these factors are inter-related and IPM seeks to resolve all pest problems using a holistic approach rather than reacting to each crisis as it arises. The expertise developed in the UK in recent years can readily be applied to develop an IPM programme tailored to the specific needs of a collection or historic house. A well planned and executed IPM programme will prevent problems or crises occurring and, in times of restricted budgets, will make much more effective use of limited human and cash resources. The reduced use of pesticides will lessen the risk of chemical damage to objects.

1 Developing an IPM strategy

An IPM programme should be relevant to the needs of the building and the collections it houses, as well as the variety of activities that take place within. It should use as much local information and expertise as possible, and it needs to be practical and achievable. It is all too easy to devise a grandiose IPM scheme that turns out to be unworkable. The programme should be considered as a process of evolution rather than a revolution, and those developing it should encourage participation by all those working on the site. With the full involvement of staff at all levels, an IPM programme has a much surer chance of success.

The key management issues relating to an IPM programme are:

- recognising and identifying priorities for action
- identifying an IPM co-ordinator and other responsible staff
- taking action on the high priorities
- establishing procedures for forward planning, financing and review

In order to develop an IPM strategy, it is important to understand and recognise the key elements of successful pest control.

The key to successful pest control

Avoiding pests - by denying them safe havens where they can live and reproduce (commonly referred to as “harbourage”) and developing procedures to keep pests out of the building

Preventing pests – by blocking their access to the building and collections

Identifying pests – the most harmful species and the signs of their presence

Assessing the problem – based on inspection and trapping, and identifying the high-risk parts of the collection and building. It is also essential to understand the life cycle of pests, especially insects.

Solving pest problems - by improving the environment to discourage the pests and carrying out appropriate treatments

Reviewing the IPM procedures – periodic assessment of the effectiveness of the strategy and modifying in order to improve it. This should include pest identification, documentation, training and funding resources, as well as surveys and treatment of infestations.

The following sections discuss each of the above in more detail.

Common pests found in UK collections

Rodents – rats, mice, squirrels
 Birds – sparrows, pigeons, starlings
 Other vertebrates - rabbits, feral cats

Vertebrates can damage collections by eating them, shredding them for nesting material and staining from their urine and faeces. Their nests contain organic detritus such as fur, feathers, plant material that will attract insects, which can then spread to the collections. The dead bodies of pests, whether death occurred naturally or through a pest control programme, pose a similar threat.

Insects

Woodworm/Furniture beetle
 Death-watch beetle
 Powderpost beetle
 Wood weevil
 Carpet beetle
 Carpet/Fur beetle
 Webbing clothes moth

Case-bearing clothes moth
 Biscuit beetle
 Cigarette beetle
 Spider beetle
 Booklouse
 Silverfish

Beetles and moths cause most insect pest problems, although other insects such as cluster flies, ants and cockroaches can cause great nuisance. The potential for damage to collections is great; entire collections of entomological specimens have been lost. More common is damage such as holes or 'grazing' on the surface of textiles. An object's value for display can be lost and important decorative or aesthetic features destroyed. Important information about the identity of objects can be lost through damage to paper labels. Managers have a duty to care for the collections; signs of pest activity are an indication that this is not being done to a sufficiently high standard.

2 Avoiding pests

It is not usually practical to totally exclude all pests from a building, so it is important that they are denied a suitable environment in which to feed and breed when they do get in. The key to avoiding pest infestations is to understand the conditions under which they thrive. By denying them the four things they need - food, warmth, humidity and harbourage - it is possible to prevent them from becoming established. The four factors are often inter-linked and achieving the right balance is not always straightforward. It is also important to develop procedures, such as quarantine of incoming material, so that a pest is not introduced as a result of normal collection activities.

Food

The search for food is often what attracts pests into a museum. Pests are normally wild creatures but they are opportunistic and if material is available that resembles their preferred natural food or nesting, they will readily adapt and possibly thrive. The material that attracts them is normally organic, such as paper, wood, leather and wool, though insects can make do with dust and fluff derived from these. The foods consumed by humans are also attractive to a wide range of pests. The key to avoiding pests is to deny them food and nesting materials by ensuring the cleaning regime, both inside and outside of the building, is of a high standard.

Special attention should be paid to areas where food is prepared, consumed or disposed of. Waste of all types must be removed regularly from the site and the disposal points (and containers) cleaned and disinfected. Ideally, human food should be kept out of the building, but as this is unrealistic, aim to limit to a minimum the number of sites where it may be stored, prepared, consumed and disposed of. Hygiene conditions in cafeterias and public areas should already be high but do not forget areas where staff take tea or coffee and eat sandwiches.

Cleaning is probably the most important part of any IPM programme. Many cleaning schedules are targeted on public areas and these may appear to be superficially clean. However, a close examination with a good flashlight will usually show accumulations of organic dirt and debris in corners, wall/floor angles and behind fittings that will support insect pests. Unused rooms and storage areas are often neglected and dirt and debris will provide food and an ideal harbourage for pests. Implement an additional programme of cleaning that focuses on the less accessible dead spaces such as ducts and chimney voids. This can be carried out on a rolling programme so that each of these areas is cleaned once every few years. Periodic deep cleaning of stores is recommended. This involves systematically emptying all drawers, cupboards and shelving, and then cleaning them, ensuring that everything that is put back (objects or packing) is as clean as is reasonable. All horizontal surfaces where dust and rubbish can accumulate should be cleaned, including the tops of storage and display units, light-fittings and ledges etc. Special care should be taken with less accessible areas such as beneath shelving units, cupboards, pallets and large objects. Vacuuming is the best method but you may need to supplement this by cleaning using a damp cloth, though care should be taken to avoid causing the relative humidity to rise to high levels for any extended period.

Vertebrate pests need water to live just as humans do, so eliminate potential sources of drinking water such as leaking pipes and taps, and cover all open drains with securely fitted wire mesh screens.

Warmth and humidity

Temperature

Cool conditions will discourage insects from breeding and any areas with temperatures of 20°C and above will encourage insect breeding. Although it may not be possible to lower temperatures in public areas, object stores should be at as low a temperature as is practical. However, ensure that the relative humidity levels are not permitted to rise to unacceptable levels. Remember that direct sunlight can cause local hot-spots even in cool areas, and preventive measures such as providing shading should be taken. Also, uneven temperatures can result in localised condensation.

Vertebrate pests are much more tolerant of high or low temperatures than insects. They have much better temperature regulatory systems and so have more potential nesting sites available to them.

Humidity

Many insects can tolerate a wide range of relative humidity (RH) and will survive for long periods in a very dry or humid environment. Some species require very particular conditions to complete all phases of their life cycle and so thrive. For example, the biscuit beetle will breed at low relative humidity but other species, such as the furniture beetle, need a damper environment. The number of furniture beetle infestations has declined in recent years due to the increased use of central heating that has reduced the average RH levels in homes and public buildings. This pest will only successfully complete its life cycle when wood is in an environment above 60% RH. It is usually only found infesting wood in basements or attics, or in objects that have been stored in outbuildings. Silverfish will only breed rapidly and cause serious problems in conditions of above 70% RH. Booklice also need a higher level of humidity than is normally found in libraries and archives. They are often found in damp basements or in localised damp areas.

By establishing appropriate environmental conditions it is possible to limit the threat from a large number of potential insect pest species. This can be achieved by mechanical means but you also need to ensure that there are not localised areas of high humidity where some pests will thrive. These can be caused by condensation, poor damp proofing, broken or missing damp-proof courses, or leaks from gutters or water, sewage and heating pipes.

Vertebrates are less likely to be inhibited by extremes of relative humidity, though high humidity is typical of the neglected parts of buildings that they exploit.

Relative humidity (RH) is a measure of the amount of moisture that a volume of air can hold expressed as a percentage of the total amount of moisture that the same volume of air can hold at the same temperature. Humans are tolerant to a wide range of relative humidity but feel most comfortable in the range 45-65%. Some insects have a strong preference for environments with a higher RH. This is because at these levels moulds and fungi have begun to attack their food sources such as wood making it easier to digest.

In general, low temperatures and drier conditions are less attractive to most pest species.

Harbourage

The type of harbourage preferred by vertebrate and insect pests, is one where they are undisturbed by human activity. Common sites where pests hide within buildings include:

- unused chimney flues and blocked fireplaces (these often contain old birds' nests that attract insects such as carpet beetle)
- heating and ventilation ducts (especially disused ones)
- cavity walls and floors
- cracks between floorboards
- unused or little frequented rooms and cupboards, particularly in attics and basements
- gaps between walls and floors
- dead spaces behind and under storage cabinets, shelving units, display cases and plinths (and even large objects)
- felt lining on boxes and felt sealing strips on doors
- old or discarded display material, particularly when covered by wool felt
- de-accessioned material which has not been removed from the site
- flowers and plants

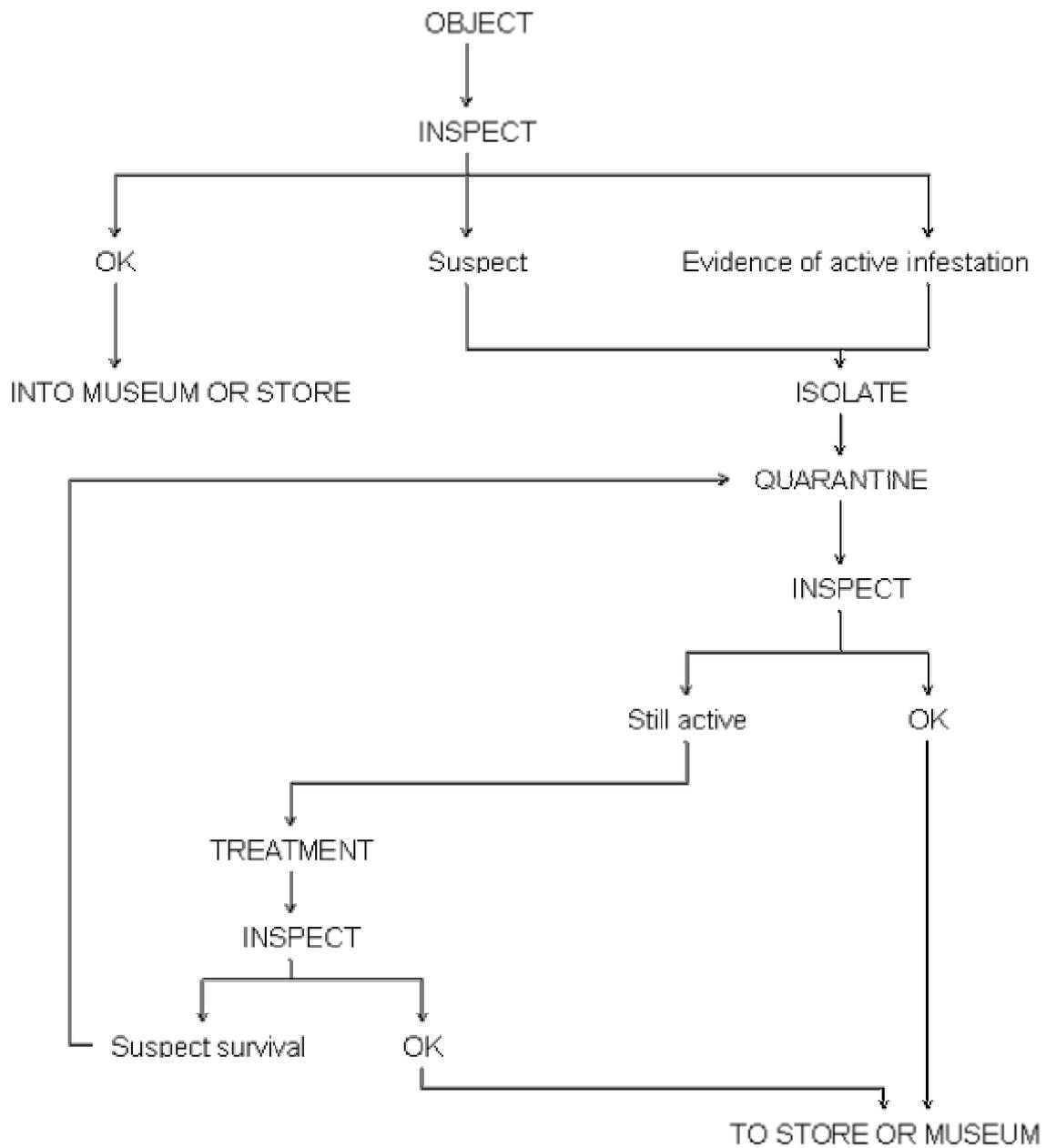
Many of these sites are difficult to inspect so you may consider a programme of adaptations. This includes fitting inspection hatches to give access to display case plinths, the space behind fitted cupboards etc, and to include these in the briefs for any improvement scheme.

Quarantine

An essential part of any pest prevention policy in a museum is to keep pests out of collections. Insects can be introduced from many sources including new acquisitions, objects on loan from other collections and items returned from loan.

Objects must be checked for infestation before being allowed into the main collection areas, whether storage or display. Inspection may reveal insect damage and clothes moth webbing, but insect eggs or small larvae are more difficult to see. Similarly, the emergence (flight) holes of wood-boring insect may be obvious but any developing larvae will be hidden in the wood. This means that some incubation period may be necessary to determine whether an infestation is active or long dead. Because it is sometimes difficult to identify when insect damage occurred, it is important that a condition report is made for all objects loaned to other organisations. This report can also be used when checking the objects on their return.

Diagram for a quarantine strategy for a collection



Establishing an inspection area

All organic material and objects coming into the building must initially be placed in a designated area and checked for signs of infestation. This area must be physically isolated from collection storage and display areas. If there is active infestation then the objects should be further isolated by bagging, clearly labelled as having an active pest, and treated as soon as possible. Pests may also be living, semi-dormant, in packing materials waiting for an opportunity to emerge when the conditions are suitable. These materials, too, will need to be checked and possibly treated or disposed of.

If there is no direct evidence of live insects but there is reason to suspect that there may be active infestation, then the objects should be isolated and allowed to incubate over a summer period. If adult insects are seen to emerge then remedial action can be taken.

Some simple treatments that can be carried out on objects in the quarantine area by museum staff (see pp XREF). Some collections have established procedures that treat all appropriate items using one of these methods, when they are acquired or on return from loan. It is most commonly applied to natural history, social history and textile items.

An IPM programme should seek to identify and resolve problems such as those described above as soon as possible. The key to this is a good standard of cleanliness and maintenance, and adopting procedures such as quarantine for objects and other materials entering the museum.

3 Keeping pests out

Most modern buildings successfully prevent the entry of pests by careful design and detailing of potential entry points such as doors, windows and vents. Building standards and the improvements to heating and ventilation systems have also played a part in creating environments that are generally less attractive to insect pests. If you are planning a new building then it is worth discussing the special needs of your collection with the architect and including this in the initial design brief. Excluding pests from older and historic buildings is often far more difficult, because of the unacceptable appearance of some proofing methods. You may need to take advice from a pest control consultant who has experience of dealing with such situations.

Good building construction practice and subsequent maintenance is essential if pests are to be kept out of a building. Check brickwork for cracks and damaged pointing and initiate remedial work, if required, as soon as possible. Ill-fitting window-frames, broken ventilation grills, poorly sealed unused openings (such as where old extraction fans were once fitted or at pipe-wall junctions) all provide easy access for a variety of pests. These defects are relatively simple and inexpensive to remedy. Ensure that all doors and windows are well fitting and kept securely closed as much as possible. In older buildings, rubber or brush seals can be rebated into door edges to provide a flexible seal. Seals suitable for larger gaps around loading bay and roller shutter doors are also available. All unnecessary openings should be blocked using appropriate building materials and techniques but ensure that essential ventilation openings are not sealed. Pay particular attention to ground, basement and to roof areas. It is worthwhile cutting back vegetation for at least three metres around the perimeter of buildings and any overhanging branches as these are often home to many potential pests. If the standard of maintenance of the outside of the building is to be high then it must be included as part of your annual planning and budget cycle.

Open-air sites and vernacular buildings such as barns or craft workshops are obviously difficult to treat in this way and alternative strategies such as trapping or using residual pesticides may be appropriate. Again, specialist advice may be necessary.

The following describes the typical exclusion methods for different types of pests.

Rodents

Specific measures to exclude rodents include:

- sheet-metal cladding fixed to the base of wooden doors, windows or walls in high-risk areas or where there are signs of gnawing. This can only be done if it is aesthetically acceptable.
- wire mesh screens and grills fitted to louvres and vents, or other openings that cannot be sealed. Steel mesh screens can usually be designed and made by a local steel fabricator. Hot-dip galvanising will extend the life of the barrier.
- insert steel mesh into gaps around pipes and in eaves to prevent access but without restricting ventilation;
- ensure that exterior drain covers and rodding caps are sound and close fitting;
- fitting metal cones or screens around exterior pipework, cables and poles. A barrier with a diameter of 200-250mm will prevent rodents climbing around it and gaining access to

entry at higher level. Barriers should only be fitted to telephone and power cables and their supports with the permission of the appropriate utility company.

Ultrasonic repellent devices are available against rodent pests but many experts consider them to be ineffective.

Birds

Measures to discourage birds from nesting or roosting include:

- netting or wire screens fitted over balconies, alcoves, light wells and other openings
- steel mesh fitted into the gaps in eaves to prevent access but without restricting ventilation
- preventing perching on ledges and sills by fitting sharp metal wire spikes and strip. Specially designed products are now readily available and may be fitted by museum staff or a commercial firm contracted in. Anti-perching gel is an alternative but this requires thorough site preparation, and regular cleaning as it rapidly become unsightly and ineffective. Spikes (pins) and wires are more expensive but more durable.
- chimney capping to prevent nesting and access. This must be designed so that any essential natural ventilation is not restricted.

Other methods such as using silhouettes of birds of prey are rarely effective in the long-term. Devices using loud noises or distress calls are likely only to be applicable in rural areas and in situations where the staff and visitors are extremely tolerant.

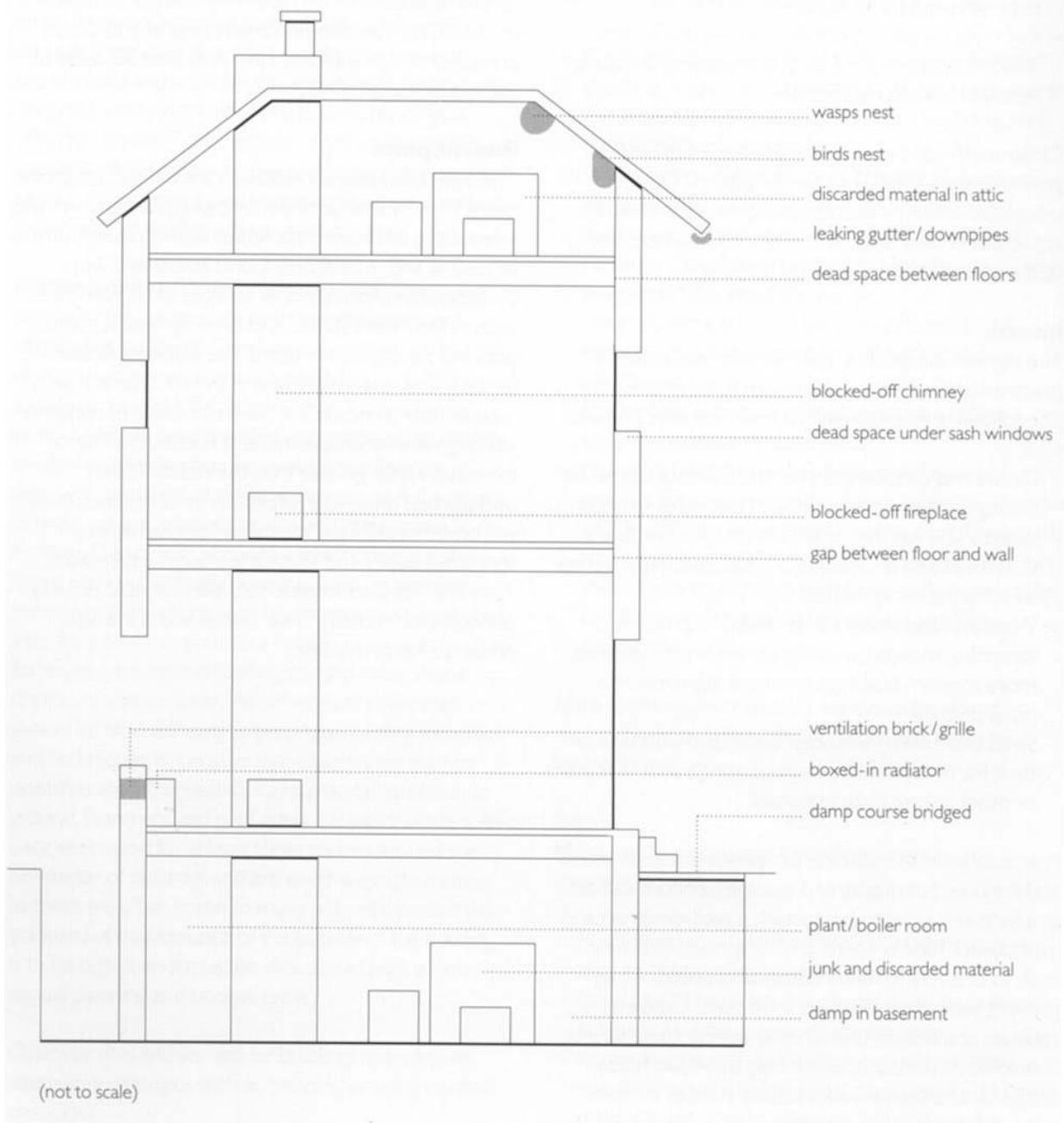
Insects

The highest standards of maintenance and building practices are essential if insects are to be excluded. The following methods will improve the effectiveness:

- doors and windows can be fitted with unobtrusive sealing barrier strips to prevent the entry of larger insects. This has the added advantage of reducing dust levels and also provides good draught proofing, so reducing energy costs.
- windows and doors can be fitted with fly mesh screening, though this is usually only acceptable on more modern buildings or where appearance is not a priority
- splits and holes in wooden doors and windows or their frames should be caulked using builders' mastic or other appropriate materials

Insects, once in the building, can penetrate small cracks and crevices but display and storage furniture can act as a further barrier to pest attack if it is well designed and maintained. For example, money spent on fitting insect-proofing seals to drawers for entomological collections may prevent serious problems in the future. Cupboards, cabinets and drawers, which may appear to sound, should be inspected because they may have hidden cracks that can allow insect access. An extensive range of rubber or fibre seal systems is available for fitting to doors, and a list of suppliers is included at the end of the publication.

Diagram of key pest points in an older building



4 Identifying pests and pest activity

An important element of any IPM programme is the correct identification of pests and signs of their presence. Vertebrate pests are relatively easy to identify but if the problem is insects then you may need the expertise of an entomologist. You should aim to have someone in your organisation that is competent in identifying the common insect pests encountered in museums. Time and money should be set aside for the appropriate training.

Rodent pests

The signs of a rodent infestation are difficult to ignore easily. They include their profuse droppings and gnaw marks. The house mouse, *Mus domesticus*, is the main cause of concern although in many collections and historic houses the fear of infestation is far greater than the reality. Given undisturbed areas with access to food supplies, mice will breed rapidly and create serious damage by shredding paper and textiles to make nest bedding. They will not discriminate between valuable objects, packaging or rubbish. Their faeces and urine present a health hazard. Infestations of brown rats, *Rattus norvegicus*, are rare in museums and usually only found associated with considerable and accessible sources of human food such as farm feed stores and catering facilities with poor refuse disposal systems. The black rat, *Rattus rattus*, is now extremely rare in the UK.

Rodents pests found in the UK					
Type	Size	Appearance	Droppings	Habitat	Food
House mouse <i>Mus musculus</i>	Length 17- 18cms, tail only slightly longer than body and head Weight: 25 grams	Colour: brown-grey with grey belly. Nose: pointed Ears: large Tail: dark in colour	6mm long,, thin and cylinder- shaped	Range only 10-15 metres from nest. Can squeeze through 10mm size gaps. Good climber and swimmer, and can jump up to 30cms. Prefers gaps behind walls and beneath fitted cupboards	Omnivores, but prefers cereals
Brown rat <i>Rattus norvegicus</i>	30-45cms. Tail shorter than body,	Colour: brown to reddish	Capsul e- shaped	Range up to 500 metres. Prefers lower	Omnivores

	Weight: 200-550 grams	grey, light grey belly. Nose: blunt Ears short and thick Tail rough, thick and lighter on underside.	, approx. 20mm long	levels and builds burrows underground.	
Black rat Rattus rattus	40-45 cms Tail is longer than head and body Weight :300 grams	Colour: Black or brownish grey with lighter belly. Nose: pointed Ears: thin and large Tail: slender	Curved with pointed ends., 12mm long	Range only 100 metres. Good climber and swimmer, and can jump up to 1.5 metres. Prefers upper levels of buildings	Omnivores

Typical signs of a rodent problem are:

- gnaw marks near the base of doors and cabinets. Rodents need to gnaw to wear down their incisor teeth, which are constantly growing. To reach food or nest sites they can gnaw through wood, particleboard, plaster and asphalt, as well as soft metals such as zinc, lead and aluminium.
- faecal droppings and urine stains
- nest made from shredded paper and textiles, normally situated in dry, dry well-concealed spaces, where they are least likely to be disturbed. Access burrows are dug in soft earth around foundations and are approximately 100mm in diameter and may be a metre deep.
- paw prints on dusty surfaces. Tracking powder such as talc can be sprinkled to confirm suspected runs.
- noises of scampering, squeaks and gnawing - usually only at night or during low occupancy levels
- rats do not normally have a distinctive odour but mice have a musty smell reminiscent of stale biscuits

Birds

Roosting or nesting birds can be a nuisance on windowsills, ledges and other architectural features. Their droppings, which are actually mostly urine through which they excrete uric acid, cause unsightly stains and can damage the building fabric. Church towers and decorative elements on the top of older buildings are regularly colonised by birds, and huge quantities of excrement and nesting material can build up over a very short time period. These pose a health hazard to humans as birds such as pigeons carry parasites and

disease. The nests, feathers and other debris attract insect pests such as clothes moths and carpet beetles, and these can move into the building and cause damage to the collection.

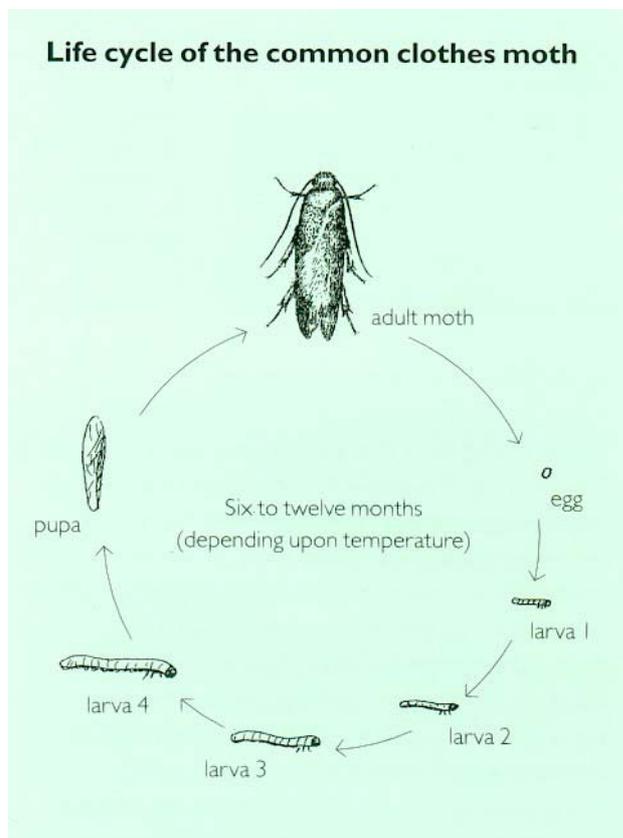
Birds such as pigeons and sparrows will occasionally find their way inside a building and be unable to escape. This bird's response is to panic, resulting in a mess of excrement, feathers and usually a dead bird. The amount of damage caused to furnishings can be extensive, and it is also distressing to staff and visitors. They can also become trapped in chimney flues, where they quickly die and become an attractive food supply for several insect pest species. The insects often spread into the building and bird corpses are one of the most common sources of insect pest infestations in museums.

The most common bird pests are:

- pigeons, starlings and sparrows are the most troublesome in urban areas
- gulls, rooks and geese may also cause serious problems of roosting and fouling in specific locations

Insects

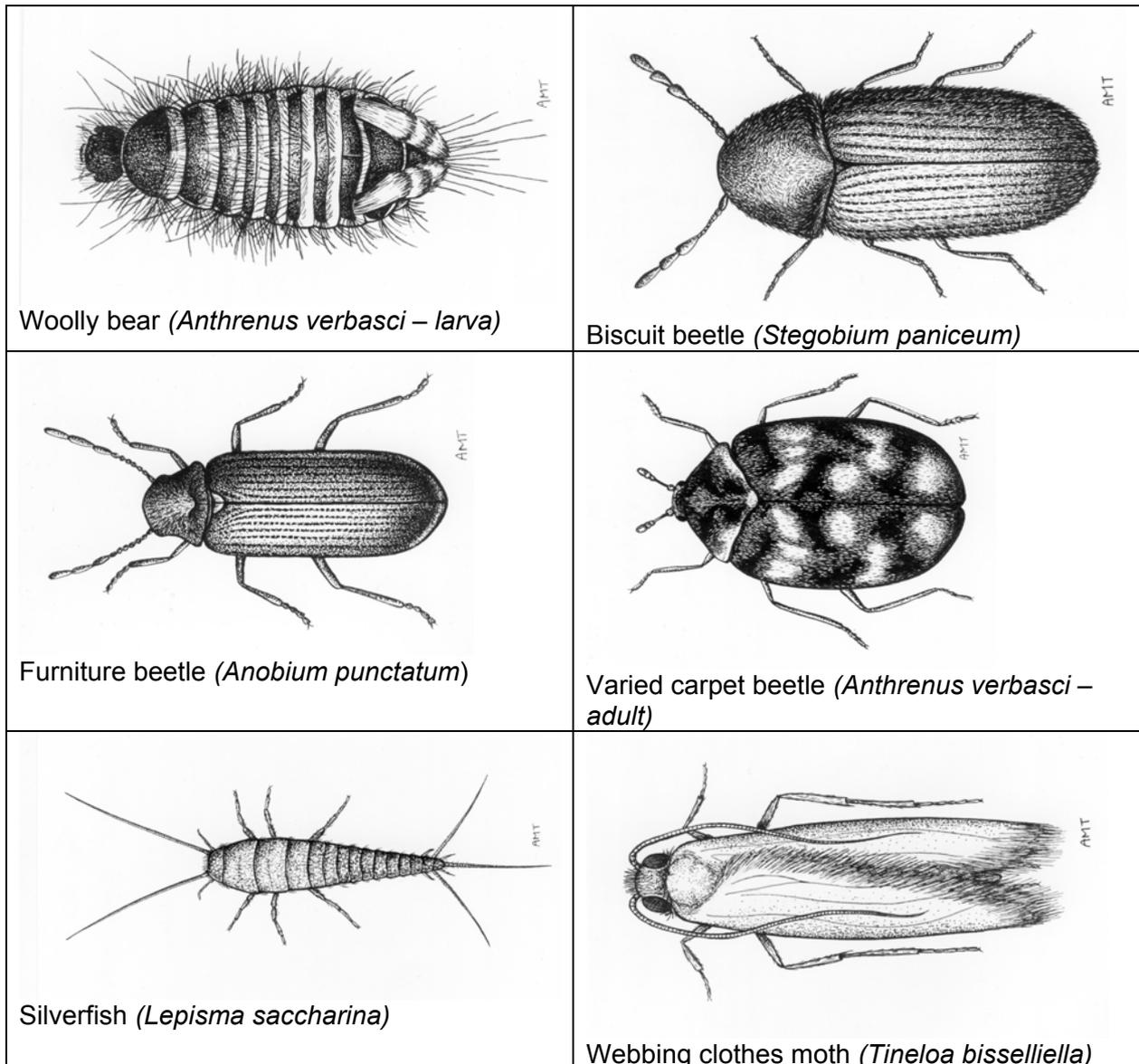
Although it is often the adult insects that are found, it is the larval stage that does the most serious damage. Adults will be more active and obvious during the summer months but the larvae, which hatch from the eggs laid by the adults, will feed and grow throughout the rest of the year.



Many of the insects found in collections or historic houses are not active pests but have simply strayed into the building. The dead bodies of flies, wasps and ground beetles may not

present a direct risk to the collection, but they can provide a substantial source of food for pests such as carpet beetles. It is not intended that this booklet should be an identification guide as there are more comprehensive sources of information, some of which are listed at the end of this publication. The following summary will help you to focus on the main insect pest problems. In all cases some expert help may be required to confirm the identity of suspected pest species and the level of activity. Contact your area museum council for sources of help. Entomologists working in museums or universities may be willing to help, or you could contact pest control consultants.

Summary of the commonest insect pests and damage in UK collections		
Pest	Type of damage	Materials damaged
Woodworm/Furniture beetle <i>Anobium punctatum</i>	Small 2mm round exit holes, gritty frass in tunnels	Sapwood of hardwoods, ply with animal glue, some composite cellulose materials and books
Death-watch beetle <i>Xestobium rufovillosum</i>	Large 3mm exit holes, rounded frass in tunnels	Structural hardwoods particularly when in contact with damp walls
Powderpost beetle <i>Lyctus brunneus</i>	Small 2mm round exit holes, fine talc-like frass in tunnels	Starchy wood
Wood weevil <i>Euophryum confine</i>	Surface damage and holes on damp wood	Damp wood, paper and books
Carpet beetle <i>Anthrenus sp</i>	Irregular holes in textiles, loose fur, short hairy cast skins of larvae	Bird and mammal skins, insect specimens, wool textiles
Carpet/Fur beetle <i>Attagenus sp</i>	Irregular holes in textiles, loose fur, long banded cast skins of larvae	Bird and mammal skins, insect specimens, wool textiles
Webbing clothes moth <i>Tineola bisselliella</i>	Large irregular holes with quantities of silk webbing tubes and gritty frass	Wool, fur and feather textiles. Bird and mammal skins
Case-bearing clothes moth <i>Tinea pellionella</i>	Irregular holes and grazed fabric with loose silk bags	Wool, fur and feather textiles, bird and mammal skins
Biscuit beetle <i>Stegobium paniceum</i>	Round exit holes and gritty dust	Dried food and spices, starchy plant specimens and seed heads, papier-mâché, freeze dried animal specimens
Cigarette beetle <i>Lasioderma serricorne</i>	Round exit holes and gritty dust	Dried food and tobacco, starchy plant specimens and seed heads, freeze dried animal specimens
Spider beetle <i>Ptinus sp</i>	Some holes or cavities, spherical silk pupal bags	Starchy dried plant specimens and seed heads, animal specimens
Booklouse <i>Liposcelis sp</i>	Scratched and eroded surface of materials	Starchy paper and glues.
Silverfish <i>Lepisma sp</i>	Irregular scratched and eroded surface of materials	Damp paper and textiles, animal glue Silverfish are very partial to paper labels on objects.
Frass is the fine powdery debris left by insects and is mostly excrement not fragments of the material it is boring through or eating.		



Illustrations © David Pinniger

There are many excellent reference guides describing insects and their habits. The article by John M. Kingsolver, 'Illustrated Guide to Common Insect Pests in Museums', included in Zycherman and Schrock (1988), the Natural History Museum publication, Mound (1989) and Pinniger (2001) are recommended. The illustrations in these, and most similar publications, show complete, undamaged specimens. It requires considerable experience to identify damaged specimens or fragments, which are typical finds of a pest inspection programme. A good magnifier (x5 or x10) and light are essential tools when trying to identifying insects.

5 Assessing the problems

To have a full appreciation of the situation, it is essential that you collect as much information as possible. This requires regular and systematic inspection of the building, both inside and outside, paying particular attention to all collection storage and display areas, and the objects housed in them. A programme of trapping can supplement this information. The results of all surveys and trapping should be documented in a central logbook, together with a record of pest control treatment to museum spaces.

As part of your pest control strategy you will need to identify:

- the parts of your collection that are most at risk
- the parts of the building that are most at risk
- activities that might present an opportunity for pests

By reviewing the above you should be able to determine the pests most likely to be attracted to the collection. Next, investigate their life cycle, seasonal activity and habits. Only then can you decide on priorities and any action that is needed. It is useful to go through the following basic checklist of pest activity:

- Is there any damage?
- Are there signs of insects or droppings from birds or rodents?
- If there are insects, are they alive or dead?
- What species are the insects?
- How many insects are there?
- Are they breeding?
- Where are they?
- How many objects are affected?
- Are they in display material?
- Are they elsewhere in the building?

Some of these questions may be difficult to answer because it is not normally possible to inspect all objects, particularly when they are in storage, and the many hidden areas in older buildings.

Materials most at risk from insect attack

Fur
 Feathers
 Animal skins
 Hair
 Wool
 Silk
 Insect specimens

Parchment and vellum
Dried plants and seeds
Dried food such as pasta or flour
Freeze-dried natural history specimens
Papier-mâché
Materials rich in starch
Sapwoods (above 60% relative humidity)
Any damp organic material

Materials, such as cotton are not attacked unless, for example, insects eat through cotton covering when they emerge from infested upholstery. Paper is rarely attacked unless it is dirty and damp.

Where to look

In general, dirty and neglected objects in dark places will be more at risk than those that are clean and in well-lit areas. Look for insects in:

- dark areas (a good flashlight is an essential tool for anyone checking for pests)
- inside folded textiles or where they are touching walls or floors

It is important to check the materials used by education and school liaison sections. They sometimes use de-accessioned objects, and products such as pasta and wool felt for creative and hands-on sessions with school groups. These are all potential food sources for pests.

Remember to check all food storage and preparation areas, including canteens, cafeterias, mess rooms and waste disposal areas, as these may be source of pests.

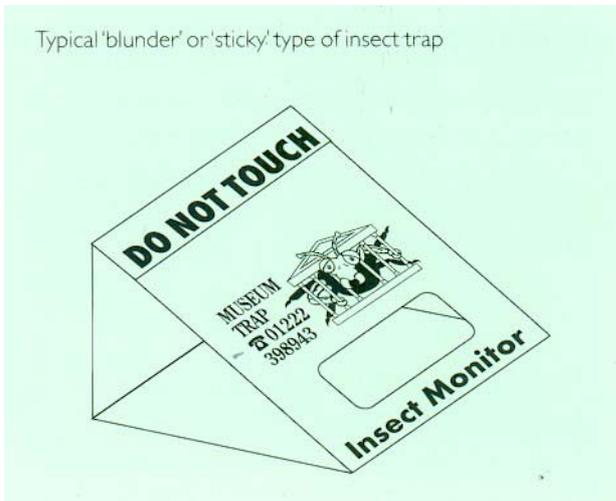
The presence of rodents is usually clear from their droppings and the damage they cause. You should check the perimeter of the building and basements for burrows, runs or signs of nests. It is sometimes worth laying traps to determine the level of activity. If you are aware that rodents are present in the building and want to check their activity, you can put down a tracking powder such as talc and look for paw prints.

Even a thorough inspection may fail to find insects that are hidden away. This is why all museums and collections should have a programme of monitoring using sticky traps to detect and find insects.

The use of traps

Traps are used to detect the presence of insects and not to control them. A range of sticky traps is available that work on the principle of the wandering insect blundering into the trap and becoming stuck on the non-toxic adhesive surface. These are designed to be placed on the floor and are most effective when placed in corners and wall/floor angles rather than in open areas. Most traps will remain effective for at least a year and need to be checked at regular intervals. It is better to check regularly every two months than to start by checking every week and then finding that the workload is too great. A minimum regime would be to check traps four times a year, in March, June, September and December. It is also important to check the stickiness of the trap at the same time as you check for pests. Dust can build up on the adhesive and render it useless.

Typical 'blunder' or 'sticky' type of insect trap



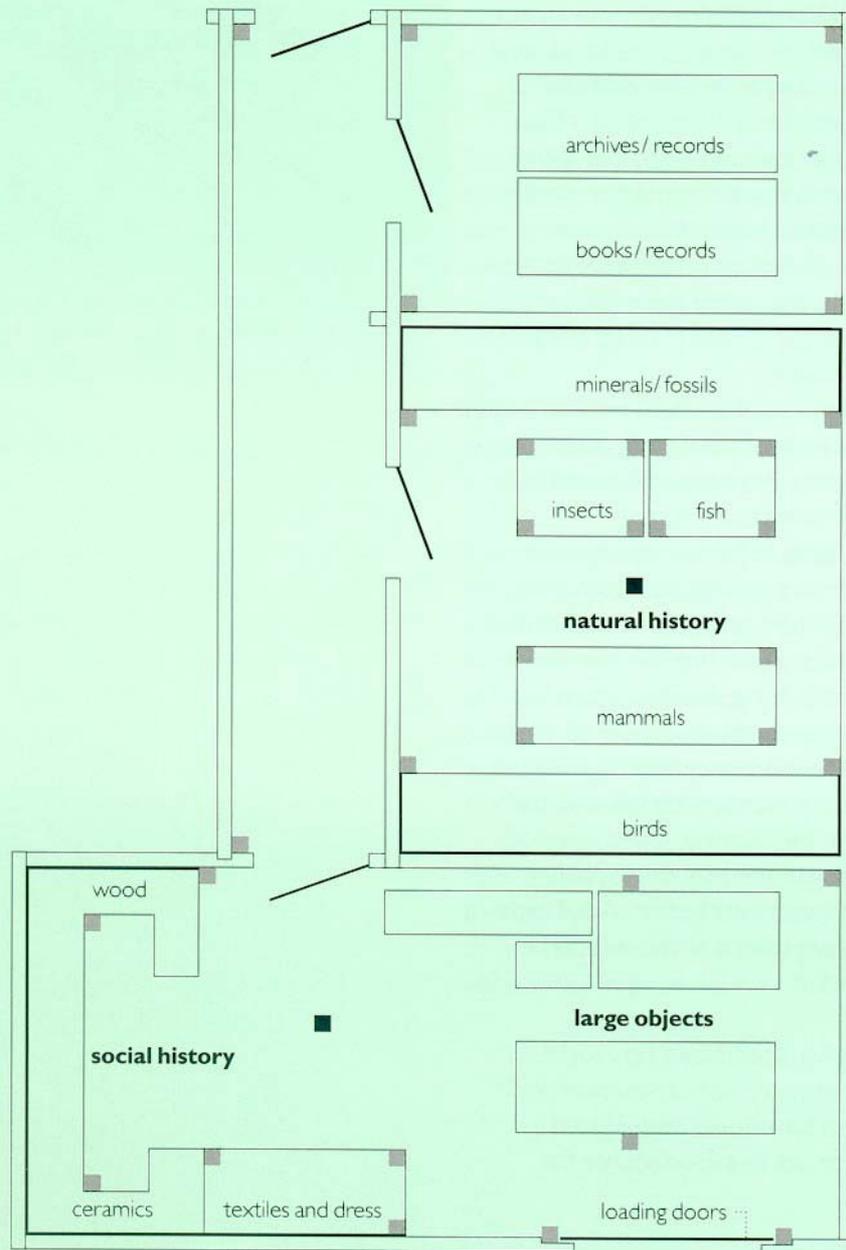
The greater the number of traps used, the greater is the chance of finding insects. However, the workload should not be underestimated and trapping programmes should be designed to be manageable. Traps should be placed in a regular grid pattern and all traps date labelled and their position marked on a plan.

Insects caught on traps should be identified and the information recorded in a log. Record whether the insects caught are larvae or adults as an adult beetle may simply have wandered in from outside. If it is a larva then it is almost certain that the species is breeding within the building. Over a period of time, careful monitoring of the traps enable a picture to be built up of insect distribution. Additional traps can be placed in areas where pests need to be more accurately pinpointed.

Large numbers of non-pest insects may be caught on traps, especially if they are near an outside door. When this happens, the traps should be replaced as the trapped insects can act as a food source for pest species.

Diagram to show placement of traps in a museum store

- position of blunder traps (all at floor level)
- position of moth pheromone trap (suspended)



(not to scale)

Pheromone traps

Many insects use chemicals called pheromones to attract mates when they are ready to breed. These chemicals are now being used as lures in traps. Pheromone lures are currently available for the furniture beetle, *Anobium punctatum*, and the webbing clothes moth, *Tineola bisselliella*. The lures are extremely effective, but will only attract the males of the target species and have no effect on other insect species. Because they attract only males, there is no risk of the pheromone traps causing an increase in insect numbers through breeding. These lures and traps are more expensive than the small sticky blunder traps but have a value for accurate monitoring and early warning of these two species in sensitive areas. The placing of pheromone traps is more complex than for blunder traps and advice from a specialist should be sought.

Traps should be used as a supplement to visual inspection. The information they provide can then be used to identify what preventative and remedial measures are required, and to establish priorities. Trap catches can show:

- the presence of a pest species;
- an increase in insect numbers in a specific area
- the spread of a pest from one area to another
- an invasion of the adult insects in summer
- localised infestation in a problem area
- the failure of a control treatment.

One trap catch may not mean much. It is only by recording results over a period of time that a full picture of the insect distribution will emerge.

Because pheromone traps are far more effective than blunder-type traps, their large catch may be disconcerting. This may cause panic until it is realised that this is reflecting trap efficiency and not a real increase in pest numbers.

6 Solving pest problems

The most effective pest control measures are preventive; the avoidance and exclusion methods described above should be the priority. Only when these methods prove ineffective should chemical treatments or trapping (for removal from site or killing) be considered. If pests are found in objects or in the building then a decision must be made on whether some remedial action is necessary and, if so, what it should be. In the first instance action should be taken to:

- isolate any objects suspected of being infested, to prevent spread of infestation to other objects
- clean infested areas and remove insect bodies, droppings and debris from the museum in a sealed container
- dispose of debris in such a way that it does not become a potential food source for new pests that might then re-infestation the museum site. Incineration is probably the best method
- decide on the most appropriate treatment

This guideline is not intended to provide an exhaustive review of all possible treatments but to provide a summary of the control options currently available.

Dealing with vertebrate pests

Chemical treatment for control of rodents is best left to professional pest control companies. But you do need to ensure that the techniques and chemicals they use are safe for your staff, visitors and the collections. You may need to take advice from a pest control consultant who has experience of working in a museum environment. Your area museum council should be able to help.

Trapping has the advantage over poisoning that the rodents do not die in inaccessible places so causing a nasty smell and acting as a food source for numerous insect pests. Great care should be taken when handling the traps and the dead rodents. Large spring traps can break a human finger and rodents are carriers of parasites and disease. Local regulations may restrict the ways you can dispose of dead rodent pests.

Squirrels – these can be trapped using ‘live’ traps. The captured mammal should be released several kilometres from the capture site.

Bats – these are protected species, so if they are a problem contact the Bat Conservation Trust.

The presence of bats may preclude the use of sticky traps or certain control measures, Treatment for woodworm or dry rot in roof spaces or the sealing of access points is covered by legislation in the Wildlife and Countryside Act, 1981.

Birds – the trapping or poisoning of birds require a license and are likely to provoke a hostile response from staff and visitors. It is not recommended. Use methods that exclude them from the building and discourage them from roosting nearby.

Feral cats – these have proved to be nuisance at a number of large sites in urban areas. The most effective strategy is to manage the situation and use the staff's love of animals. Appoint someone to be responsible for the feline population and give them an appropriate budget. Establish a feeding point and latrine area and keep these clean. Employ humane methods to trap the animals. The captured animals should be examined and treated by a vet, and neutered. This will stabilise the situation and it may be possible to reduce the population by moving individual cats that have been re-domesticated to new homes. In large institutions it is important to keep all staff informed and to encourage their co-operation. This has proved a successful strategy for several large museums, and had the support and encouragement of staff and trustees.

What if there are insect pests in the building?

Targeted treatment using an approved insecticidal dust or spray can be very effective in reducing the numbers of insects. However, insects mostly live in places where it is difficult to apply insecticides and will only come into contact with it when they wander across treated surfaces. Locations to pay particular attention to include:

wall/floor angles, cracks in woodwork - these can be treated with a residual insecticide; dead spaces in ducts and under cabinets - can be treated with an insecticidal or desiccant dust. These are both very useful for little frequented areas because it is important that the dust is not disturbed by pedestrian traffic. Desiccant dusts have the advantage of being low hazard to humans.

structural timber can be treated for infestations of woodworm by application of a suitable insecticidal fluid;

carpets, wool felt underlay and curtains – infested textiles that are not museum artefacts can be treated in situ with an appropriate insecticide.

The use of aerosols or airborne sprays is not recommended, they achieve little control of most museum pests and cause indiscriminate contamination of objects and the general environment.

Dichlorvos [Vapona] slow release strips are now banned in the UK and must not be used.

Staff can safely carry out many localised treatments but a competent contractor should carry out large-scale treatments.

Examples of residual insecticides				
Insecticide	Type	Formulation	Use	Example of Brand name
Permethrin	Pyrethroid	Dust	Dead spaces	Coopex
		Microemulsion	Wood, textiles	Constrain
Bendiocarb	Carbamate	Dust	Dead spaces	Ficam D
		Wettable powder	Wall/floor angle spray	Ficam W
Chlorpyrifos	Organophosphorus	Encapsulated	Wall/floor angle spray	Empire 20
Silica aerogel	Desiccant	Dust	Dead spaces	Agroduct

Residual insecticides are formulated to be effective when applied and for some period afterwards. The duration of their efficacy varies. Available types include:

- Desiccant type insecticide, which is an inert siliceous powder that absorbs part of the insect's outer protective wax coating. This causes dehydration and eventual death.
- Encapsulated formulations that incorporate the insecticide into microscopic porous plastic beads. The insecticide slowly diffuses out or is released on being ruptured
- Wettable powder formulations mix an insecticide with an inert powder and a wetting agent. Water is added to form a suspension that can be sprayed.

Insect repellents

Substances such as naphthalene and paradichlorobenzene have been used in mothballs or moth flakes for many years to repel insects such as clothes moths and carpet beetle. There is some insecticidal effect at very high concentrations and both chemicals will repel adult clothes moths. However, larvae deep in garments, folded fabrics and animal skins will not be affected. There is concern about the hazards to humans of long term exposure to these chemicals and their use is under review.

Insects are repelled by high doses of some traditional plant-derived materials such as cedarwood oil and aromatic herbs' including lavender, bay, rosemary and wormwood. These are currently being re-examined for efficacy and repellency. It is worth noting that some chemicals derived from plants are as toxic as synthetic pesticides and the oils may have deleterious effects on objects.

Treating items in the collection

The choice of remedial treatment will depend upon the severity of the infestation, the type of material and the value of the object. The treatment of objects should only be carried out after taking the advice of a conservation or collections care specialist.

In many situations, the application of an appropriate residual insecticide such as permethrin micro-emulsion will be sufficient to tackle an isolated outbreak of insect infestation. This treatment will kill emerging furniture beetle adults and may kill larvae and pupae near the surface of the wood. Such treatments may be appropriate for bulky and robust wooden objects but may be less suitable for delicate objects and fine furniture, or if the outbreak is severe or deep-seated.

Recent developments in the food preservation industry and by museum researchers mean that museums now have a number of options for treatments that will kill all pests in objects, if they are carried out correctly.

Low temperature

This method will kill all stages of an insect's life-cycle and is being used routinely in some museums to fumigate textile, social history and natural history collections. The objects are sealed in polythene (other plastic films such as polyester can be used but not PVC) and exposed to temperatures of -30°C for three days or at -18°C for at least two weeks. It is not necessary to treat objects through two freeze-thaw cycles at -18°C as was once recommended. A domestic chest freezer is more efficient than an upright type but neither will normally reach a temperature lower than -18°C . Commercial freezers operate at around -30°C . It is not advisable to rely on a freezer's built-in thermometer but to use a separate device. Objects should not be removed from the bag until they have returned to room temperature and there is no risk of condensation. Some large museums own freezer chambers, and the National Museums and Galleries on Merseyside now offer this form of pest control treatment as a commercial service.

Elevated temperature

All insects will be killed at temperature above 45°C . Objects can be treated in 24-hours without bagging in a special humidity-controlled chamber at 52°C in the Thermo Lignum process. Some less sensitive objects can be treated in an oven at 52°C if they are bagged in the same way as for freezing.

Carbon dioxide

This treatment involves placing objects in an environment with a concentration of at least 60% carbon dioxide. It is usually carried out in a special gas-tight plastic bubble or tent. Carbon dioxide has no deleterious effect on objects at normal temperature and relative humidity. Long exposures of three weeks or more may be needed to kill all pests.

Nitrogen

The treatment involves placing the object in a nitrogen atmosphere and kills the insects by depriving them of oxygen. Insects require oxygen to live but they can tolerate very low concentrations so the treatment is effective only at nitrogen concentrations of greater than 99%. The treatment must be carried out in specially constructed chambers or in cubicles made from a barrier film that has low oxygen-permeability. The nitrogen must be humidified, and the oxygen levels carefully monitored and controlled using an oxygen meter. As with carbon dioxide, exposure times need to be longer at lower temperatures. Nitrogen gas is used extensively in industrial processes so it is relatively inexpensive and readily available.

A variation on the nitrogen anoxia treatment that is suitable for smaller objects is to seal the item in bags constructed from the barrier film together with an oxygen scavenger such as Ageless™. This product contains finely divided iron compounds that react with the oxygen and remove it from the atmosphere. The insects die through lack of oxygen. The procedure is only useful for small items, as the oxygen scavenger is expensive. Ageless™ is produced by the Mitsubishi Company and different grades are available for different situations.

Methyl bromide

Methyl bromide is extremely toxic and a very effective fumigant for pests. However, it has been identified as an ozone-depleting chemical and is no longer available in many countries, including the UK. It has been used in the past for fumigation of soil, glass-house crops, horticultural compost and even commercial aircraft. Museum objects were treated with methyl bromide in a chamber or special gas-tight bubble with a 48-hour exposure.

Phosphine

Objects are sometimes fumigated using phosphine. This is done either in a special chamber or under gas-proof sheeting. The temperature must be above 20°C to avoid over-long exposure to the chemical. At high relative humidity phosphine can corrode metal objects and it is only suitable for treatment of some textiles or natural history specimens.

Note

Fumigation using phosphine or carbon dioxide can only be carried out by trained and licensed operators. Staff with appropriate training and experience can safely carry out freezing and nitrogen treatments.

7 Implementing IPM

An IPM programme should not be seen as a rigid set of rules and procedures that once established are immutable. It is essentially an evolving process that should apply your knowledge of the local situation and be adaptable to changing needs and priorities.

Implementing an IPM programme in a large collection can be a daunting task. It is therefore important to identify priorities and plan to cover the building in achievable steps. In many cases it has taken several years to develop and implement a programme in a large collection. It has been achieved by initially selecting one department or collection area, demonstrating that IPM is effective and achievable in that area and then adapting the programme for other areas until all parts are covered.

A suggested plan of action is as follows.

Survey the situation

It is important to:

- Obtain a plan of the building and grounds or make survey sketches. Include galleries, stores and any other areas such as out-buildings.
- Carry out a preliminary survey to identify pest access points, and high-risk areas and objects. Record this on the plan.
- Place monitoring traps.
- Plan a detailed inspection schedule for all areas.

Develop or assess IPM procedures

You should:

- Check cleaning regimes and modify if necessary.
- Review existing pest control contracts.
- Examine the pattern of movement of objects into and out of the collection.
- Establish a quarantine strategy, if one is not in place.
- Explain to key personnel the objectives of IPM and encourage their co-operation.
- Form a small team to aid communication and spread the IPM load. This can, for example, include conservation, collection management, buildings management and gallery staff.
- Identify training /awareness raising needs.
- Write an outline strategy for short-term and long-term IPM.
- Identify budgets that may contribute funding for IPM. For example, training, buildings maintenance, collections care, storage furniture etc.

When budgeting for IPM it is essential to find out what is currently being spent on existing pest control contracts and any fumigation treatments. In many cases, a good IPM

programme can use this money more effectively and efficiently. Buildings' and Estates' Officers normally deal with pest control contracts. It is essential that these contracts be examined closely to ensure that they are geared to the needs of a museum. The contractor may not fully understand the limitations imposed by the specialised needs of the collection and some treatments may be ineffective or harmful to objects. If you are in doubt about priorities, surveying, treatments or implementing IPM, you can obtain specialist advice from a pest management consultant or through your area museum council.

It is also important to consider the overall costs relating to caring for collections. An IPM programme will help avoid the neglect and resulting deterioration of objects, and consequently increased expenditure on remedial conservation.

Training

Successful IPM involves all staff. Training can range from attending an intensive five-day IPM course to a 30-minute awareness talk for cleaners and warding staff. One person should be identified as the co-ordinator and chief contact for IPM matters. Some IPM tasks such as monitoring can be shared by several members of staff, depending upon the size of the collection and staff structure. If contractors are involved then it is important to monitor that the work is being done as specified and their staff are adequately trained.

Documentation

All pest treatments of areas within the museum and all monitoring data should be recorded by the IPM co-ordinator. This can be done in a central logbook, on customised forms or using a spreadsheet programme such as Excel. Plotting insect pest occurrences on to a plan of the building (best of all on transparent film) will help you to visualise the situation and show how it develops over time. An annual summary of pest incidence and attack should be produced and sent to relevant staff and trustees.

Any pest control treatment for pests on museum objects should be recorded in the object's documentation. The occurrence of an insect pest on a returned loans or newly acquired objects should, of course, be documented and the previous owner or the borrower informed.

Health and safety

The IPM co-ordinator should be responsible for ensuring that all monitoring and treatments are undertaken safely. Ensure that you and all of your colleagues are aware of the following:

- The use of chemicals must be justified and recorded. This is required under the Control of Substances Hazardous to Health Regulations (COSHH) 1994.
- Hazard data-sheets should be obtained from the supplier for all of the chemical products used, and their contents noted.
- Under the Control of Pesticides Regulations 1986, many chemicals are approved for use only by licensed, professional operators.
- Instructions and information on pesticide container labels relating to application and use of protective clothing must be read and followed.
- All pesticides and other chemicals must be stored safely and securely.

If your organisation has stocks of pesticides then check that they are within any 'use-by' limit and that they are still permitted pesticides. Some may now be banned and must not be used. These should be disposed of correctly as stated in the Control of Pesticides Regulations 1986. Your local authority may have special arrangements for disposing of such material. Otherwise, a commercial waste disposal contractor must be used.

IPM and the future

Because of the effects of some chemicals on staff, objects and the environment, there will be increasing pressure to move away from persistent and toxic pesticides. The development of an IPM programme based on the principles outlined in this booklet will enable collections and buildings to be cared for in ways that are safe and effective. There are exciting new developments that are now becoming available for the detection, prevention and control of pests and it is important that those responsible for developing IPM in museums do not work in isolation but share their experiences with others.

Further reading

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Useful addresses

Bat Conservation Trust
Cloisters Business Centre
8 Battersea Rd
London SW8-4BG
Tel: 0171 627 2629

British Pest Control Association
1 Gleneagles House, Vernon Gate, South Street, Derby, DE1 1UP
Tel: 01332 294288
Fax: 01332 295904
Email: enquiry@bpca.org.uk

Health and Safety Executive
Pesticides Registration Section
Magdalen House
Stanley Precinct
Bootle
Merseyside L20 3QZ
Tel: 0151 951 3535
Fax: 0151 951 3317
Email info.prs.@.hse.uk
Internet: <http://www.open.gov.uk/hse/hsehome.htm>

HSE Books
Sudbury
Suffolk CO10 6FS
Tel: 01787 881 165
Fax: 01787 313 995
Email
Internet: <http://www.open.gov.uk/hse/hsehome.htm>

National Museums and Galleries on Merseyside
Conservation Centre
Whitechapel
Liverpool L1 6HZ
Tel: 0151478 4999
Fax: 0151 478 4990
Internet: <http://www.connect.org.uk/merseyworld/AandE/museums>

Suppliers

Historyonics

17 Talbot Street, Pontcanna, Cardiff CF1 9BW

Tel: 02920 398943

Fax: 02920 218672

Suppliers of insect traps. This company has considerable experience of museum pest problems.

Killgerm Chemicals

PO Box 2, Ossett, West Yorkshire WF5 9NA

Tel:

Fax:

Killgerm is a large company supplying a comprehensive range of monitoring and control products for insect and vertebrate pests.

Network Pest Control Systems

Unit 9b, Bankhall Park

Wharf Street

Warrington

WA1 2DG

Tel: 01925 411 823

Fax: 01925 414 914

Email: info@network-pest.co.uk

This company specialises in bird-proofing systems.

Suppliers of Ageless™ and oxygen barrier film

Conservation by Design Ltd

Timecare Works

60 Park Road West

Bedford MK41 7SL

Tel: 01234 217 258

Fax: 01234 328 164

Suppliers of sealing strips for door, windows, and roller shutters

Sealmaster, Pampisford, Cambridge, CB2 4HG

Tel: 01223 832 851

Fax: 01223 837215

Mann McGowan Fabrications Ltd Intumescent House, 9 Springlakes Estate,

Deadbrook Lane, Aldershot, Hampshire GU12 4UH

Tel: 01252 333 601

Fax: 01252 322 724

Kleeneze Sealtech Ltd, Ansteys Road, Hanhan, Bristol BS15 3SS

Tel: 0117 947 5149

Fax: 0117 960 0141

Schlegel (UK) Engineering Ltd, Henlow Industrial Estate, Henlow Camp, Bedfordshire SG16
6DS
Tel: 01462 815 500
Fax: 01462 811 963

Heat treatment pest control

Thermo Lignum UK Ltd
Unit 19 Grand Union Centre, West Row, Ladbroke Grove, London, W10 5AS
Tel: 0181 964 3964
Fax: 0181 964 2969
Email 1015631474@compuserve.com

Museum pest management consultants for advice and treatment

David Cross
IGROX
42 Claydon Business Park
Ipswich
Suffolk, IP6 0NL
davidcross@igroxpmd.co.uk

D. B. Pinniger
83 Westwood Green, Cookham, Berkshire SL6 9DE
Tel: 01628 526066

IPM Checklist

In the beginning

- Appoint an IPM co-ordinator
- Put together a team to prepare, co-ordinate and implement the pest control programme
- Tell the rest of the staff what you are doing and why

Survey the situation

- On a plan of the building and grounds indicate galleries, stores and any other areas such as catering points and refuse disposal points, etc
- Make a preliminary survey to identify pest access points, and high risk areas and objects, and record this information on the plan
- Make an initial survey of building, adjacent grounds and collections for signs of pest activity and assess level of activity

Initial steps

- Isolate any infested material or areas that are of immediate risk and arrange for remedial treatment
- Determine cause and origin of infestation
- Identify funds for immediate preventive works

Preventive measures

- Screen windows, ventilation openings, eaves, etc and install bird netting if necessary
- Undertake necessary repairs and maintenance to the building fabric
- Check cleaning regime and modify if necessary
- Examine the pattern of movement of objects into and out of the collection
- Review existing pest control contracts

On-going activities

- Inspect all areas, and record and report findings
- Enhance your monitoring by instituting a trapping programme
- Operate a quarantine programme
- Take action to eradicate the inevitable minor pest infestations
- Maintain records of monitoring and treatments

- Keep staff and volunteers up to date with what is happening and encourage their co-operation
- Operate a training and awareness raising programmes
- Monitor and review IPM programme and consolidate into forward planning process

Longer term initiatives

- Write down your IPM strategy and include it in your collections management policy
- Formulate plans to deal with serious outbreaks

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