

Pests





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Cover Golden spider beetle *Nipteus hololeucus*

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Managing pests in paper-based collections

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1 Introduction

Many collections of old books, manuscripts and archives will show signs of damage by insect pests. Holes in books and bindings, large chewed areas and scraped surfaces are all evidence of pest attack. Much of this damage is probably historic and no longer active, but it is important to understand pests and so prevent further damage to collections. Different species of insects have different requirements of food, temperature and humidity. They are also influenced by the climate and building they are in. Infestation in books can be controlled by both physical and chemical treatments, but the aim of anybody responsible for collections should be to prevent pests from becoming established and causing damage. Prevention by using Integrated Pest Management (IPM) is cheaper and far more effective than expensive remedial treatment.

2 What is damaged or at risk?

Clean, dry paper is not very nutritious for most insects. However, additional materials applied to paper or used as adhesives, such as gelatine or starch, will provide nutrition. Wooden boards, shelving and furniture all provide nutrition, as do textiles. Books with a high content of animal glue in bindings are particularly vulnerable to

attack from a number of pest species, including carpet beetles and spider beetles. The glue will also make the books more attractive to woodborers such as furniture beetle. When paper is damp it can support mould growth, which is eaten by some insect species, causing damage to the paper surface at the same time. Termites have the ability to digest paper and books even when they are clean. Books made from parchment and vellum can be vulnerable to attack by insect pests because of the high protein content.

3 What are the pests?

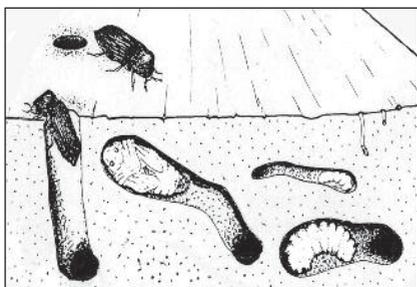
The insect pests which attack books include those which will consume and live in paper and those which live on additional material applied to the paper, such as animal glue, starch and gelatine. The primary pests which attack paper are woodborers such as Furniture beetle, *Anobium punctatum*. Although Anobiid beetles which attack books are often referred to as 'bookworms', this is a generic term and does not apply to any particular species. In hotter climates, termites can be extremely destructive. Drywood termites will attack books, furniture and wooden shelving within a building. Subterranean termites live in damp conditions which they create in tree stumps and building timbers; they can then spread into books and shelving. Insects which attack adhesives and coatings include the biscuit beetle, *Stegobium paniceum*, which will also tunnel through the paper. Silverfish and booklice will damage paper and books by grazing on the surface. They eat surface coatings, organic debris and microscopic mould, but by scraping away at the surface they can damage and create holes in paper. When conditions are extremely damp, paper may be damaged by woodlice, and in extreme cases, snails. A short visual guide to insect pests and their associated damage is given on pages 8–9.

Pests which attack books

Furniture beetles

The common furniture beetle or woodworm, *Anobium punctatum*, is widespread in most temperate countries where it infests buildings, furniture and wooden objects and may also attack books. The larvae make tunnels in compressed paper and take

2-3 years to complete development depending upon the food and the conditions of temperature and moisture content. Adults emerge in spring leaving small 1.5-2mm exit holes with a pile of frass (insect excreta) below the hole. *Anobium* infestations will survive in cool, damp conditions but do not thrive in dry conditions with humidities below 55%. Outbreaks of woodworm activity are usually confined to collections which have been brought in from damper storage in cellars, outbuildings or areas where there are leaks, condensation and poor air circulation.



Life-cycle of the common furniture beetle



Frass left by emerging adult furniture beetles

Anobium larvae will attack wooden shelving and wooden boards in books, preferring starchy hardwood and softwood. Plywood or bindings with animal glue are particularly susceptible because of the added protein and can be severely damaged. Other Anobiid beetle species which have recorded as attacking books are *Xestobium rufovillosum* (death watch beetle), *Catorama herbarium* (the Mexican book beetle), *Nicobium castaneum*, and *Gastrallus imarginatus*.

Wood weevils

These are small, cylindrical, black beetles with a long snout called a rostrum. There are two similar species, *Euophryum confine* and *Pentarthrum huttoni*, which are usually found in damp wood but will also damage damp books. The exit holes are very small and the damage often looks eroded and irregular. They are found in damp locations such as basements and are an indicator of high moisture levels.

Termites

Termites, well known and feared in tropical countries, are commonly known as 'white ants', although they are not ants but members of a group called the Isoptera. They live in colonies which may have millions of individuals with a complex social structure. They are the world's most serious and destructive pests of structural timber. In many museums, libraries and archives, termite infestation of the buildings has spread to display and storage furniture, archives and book collections, which are then seriously damaged. There are many different species of termites and they are generally divided into two pest types with distinctly different life styles – drywood and subterranean. Subterranean termites cause the greatest damage to buildings whereas drywood termites often cause the greatest damage to collections. Termites are not a problem in cool temperate countries and are absent from Canada, Northern Europe, the Russian Federation countries and Northern Asia. The most severe problems are encountered in countries with warm temperate and tropical climates.

Drywood termites

Drywood termites, which include the species *Cryptotermes* and *Kalotermes*, bore tunnels and galleries in wood in many directions, and also live in compacted paper and books. Although some faecal pellets are scattered in the passages, large quantities are often stored in chambers or thrown out of the wood through 'toilet holes'. Drywood termites can be identified by the piles of these pellets which are the shape of poppy seeds. The nests and colonies are constructed entirely within the wood or paper and they do not forage widely from infested material.

Subterranean termites

Subterranean termite colonies need to live in contact with soil and some species, including *Reticulitermes*, *Coptotermes* and *Macrotermes*, will spread from the natural environment of soil and trees to the woodwork of buildings. Many species require fungi in their diet which is produced on decaying wood or paper within the nest. They need to maintain high levels of moisture in the colony for the development of fungi and to prevent the desiccation of the nymphs and workers. This leads to the characteristic tube-building habitat of subterranean termites. These tubes, which may be some metres in length, are constructed of soil and faecal material which protect the termites as they pass

between nests in soil to the food sources of wood or paper. As their name implies, subterranean termites are found near or below ground level and seldom spread above the lower floors, this means that collections in basement areas are particularly at risk. They may invade libraries and archive stores and completely destroy the inner parts of books and bound archives, just leaving an outer skin of bindings or packaging.

The eradication of termites and their subsequent exclusion can be extremely difficult and usually requires the services of a pest control contractor who specialises in termite problems.

Pests which graze on books

Silverfish

Silverfish (also known in some countries as fish moths) are always associated with damp conditions and they require localised humidity above 70-80% to breed and multiply. They are primitive, scaly, wingless insects (10-15mm) with three bristles at the tail end. Silverfish feed on starch, glue, ink and microscopic moulds. There are a number of silverfish species including *Lepisma* and the larger *Ctenolepisma*. The related firebrat *Thermobia* will also damage paper, photographs and bindings but needs hotter and drier conditions. Silverfish damage can be recognised by the ragged, scraped surface areas and irregular holes in paper. They may preferentially eat some areas with glue or ink which are more nutritious. They are serious pests in humid countries, but in temperate climates they are usually confined to damp rooms and basements.

Book lice

There are a number of different species of booklice which have very different habits and needs. *Liposcelis bostrychophila* is the most common species in heated buildings. The adult is wingless and very small (less than 1mm). They develop through a series of nymphal stages which feed on microscopic moulds on a range of substrates including flour, paper and cardboard. Populations of *Liposcelis* can increase very rapidly if temperatures rise above 25°C, and this gives rise to apparent population explosions. Although damage by a few booklice may be negligible, large numbers of booklice will graze the surface of books and papers. In addition, squashed bodies will stain materials and may encourage moulds.

Pests which attack animal glue

Carpet beetles

The most common species found in Great Britain is the varied carpet beetle, *Anthrenus verbasci*, a destructive pest of textiles and natural history specimens. There are a number of other species of *Anthrenus* including the furniture carpet beetle, *Anthrenus flavipes* and the Guernsey carpet beetle, *Anthrenus sarnicus*. Adult *Anthrenus* are 2-3mm long and covered with grey and gold scales; they fly in warm weather and may frequently be found on window sills. The eggs hatch into short, fat, hairy larvae which are extremely small (less than 1mm) and can get through very small cracks. They will grow up to 5mm long and are often referred to as 'woolly bears'. As the larvae grow they moult leaving empty hairy, cast skins which may be the first signs of attack. The larvae will wander widely and chew holes in bindings and mounts with animal glue. They eat other protein-rich material such as wool, fur, feathers, silk and skins. They will also feed on dead insects and are often found in birds' nests.

Hide and leather beetles

The hide or leather beetles (Dermestes) as the name suggests, will attack leather and skins but they will not feed on tanned leather in good condition. They will live on dead animals and also attack book bindings with animal glue. The adults are black or dark brown and larger (6-10mm) than carpet beetles. The larvae are also dark brown and large and very hairy. They have a very destructive habit of tunnelling into objects to pupate and as they are large, they make big holes.

Clothes moths

A number of species of moth will attack and cause serious damage to textiles although they very rarely damage books and papers. The case-bearing clothes moth *Tinea pellionella* and the common or webbing clothes moth *Tineola bisselliella* are two of the most important species and both have a wide distribution. Other moth species such as the white-shouldered house moth, *Endrosis sarcitrella*, and the brown clothes moth, *Hofmannophila pseudospretella*, are very common in old houses. The larvae will occasionally tunnel into bindings but very rarely cause damage to clean, dry materials.

Pests which live on starch and dried food

Biscuit (or drugstore) beetles

The biscuit beetle or drug-store beetle, *Stegobium paniceum*, belongs to the Anobiidae, the same family as the common furniture beetle or woodworm, *Anobium punctatum*. Unlike woodworm larvae, which eat wood and cellulose, those of the biscuit beetle bore into hard dried vegetable material including biscuits, cereal grains, nuts and dried plant specimens. Biscuit beetles will attack papier maché and starch-rich composite board in books and boxes. The larvae are white and curved but are not usually seen as they live in tunnels in hard materials. Adults are reddish-brown and 2-3mm long and emerge leaving neat, round exit holes in objects. When it is warm (above 22°C) they are very active and will fly to light sources.

Spider beetles

Spider beetles are common in birds' nests and general debris in attics, basements and stores where they will feed on a wide range of vegetable and animal detritus. The adults are 3-5mm, hairy and superficially spider-like. The brown, hairy Australian spider beetle *Ptinus tectus* and the golden spider beetle *Niptus hololeucus*, are common in many temperate countries. The larvae are similar in appearance to those of the biscuit beetle and they will also bore holes and cavities in paper and wood before pupating in a globular silk cocoon.

Pests associated with mould and high humidity

Fungus beetles and Plaster beetles

There are many species of these small brown beetles, 1-2mm long, including the common *Mycetophagus sp* and *Adistemia sp*. They feed on microscopic moulds and are often found in large numbers when papers and books are stored in damp areas. As they graze, they may cause some superficial damage to the surface of paper.

Woodlice

These are not insects but belong to a group called the Crustacea which also includes shrimps and crabs. There are a number of species that come into buildings which are greyish-brown and range in size from a few millimetres to 15mm. Woodlice live in damp, rotting vegetation and wood and may graze on damp paper and cardboard.

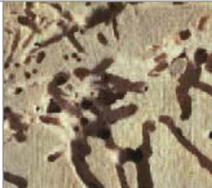
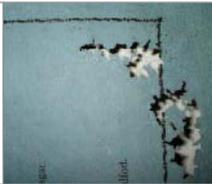
They are often found in basements or near doors and windows where they have wandered in from damper outdoor environments. As they cannot survive for long in dry conditions, most soon die of desiccation without causing any damage. If there is a persistent problem of live woodlice, the area should be investigated as there is probably local high humidity and rotting wood.

Rodents and birds

Rodents and particularly mice, will seriously damage paper when the female mice collect and shred paper to make nests. They will also damage books by their habit of gnawing hard objects to keep their teeth sharp. Additionally, mouse urine and droppings can stain paper and also present a disease hazard. Birds will rarely directly damage books but droppings can be unsightly and corrosive.

Visual guide to insect pests of paper-based collections and damage

	<p>Environment: Dry and hot. Adults emerge spring and summer (crawl and fly to light) Adults: Reddish brown, 2–3mm</p>		<p>Larvae attack papier maché and starch-rich composite board in books and boxes.</p>
Biscuit beetles			
	<p>Environment: Tolerate lower temperatures than most species (<10°C). Adults: Dark or golden brown, hairy 3–5mm</p>		<p>Larvae eat dried food and plant material, and will bore into wood and paper.</p>
Spider beetles			
	<p>Environment: Warm, found in birds' nests in chimneys and attics. Adults: Grey and gold scales, 2-3mm. Larvae: Brown, short, fat, hairy, <1mm – 5mm</p>		<p>Larvae eat wool, fur, feathers and skins and will attack bindings with a high content of animal glue.</p>
Carpet beetles			

	<p>Environment: Damp. Adults emerge spring. Adults: Dark brown 3 – 5mm</p>		<p>Larvae attack wooden book boards, shelving, frames and compressed paper.</p>
<p>Furniture beetles</p>			
	<p>Environment: Very damp. Adults: Black, 2 – 3mm</p>		<p>Larvae and adults eat wood and paper.</p>
<p>Wood weevils</p>			
	<p>Environment: Tropical and warm temperate.</p>		<p>Termite infestation of buildings spreads to display and storage furniture, book and archive collections.</p>
<p>Termites</p>			
	<p>Environment: Very damp, cool, dark. Adults: Silver, 10 – 15mm</p>		<p>Adults and nymphs eat moulds and surface coatings, pastes, and adhesives.</p>
<p>Silverfish</p>			
	<p>Environment: Damp, hot, dark. Adults: Brown <1mm</p>		<p>Adults and nymphs eat organic debris, moulds and surface coatings.</p>
<p>Booklice</p>			

4 Temperature, relative humidity and housekeeping

Insect development is directly related to temperature. In hot conditions insects will feed more and breed more rapidly. In cool conditions insects slow down and may stop feeding and growing. Relative humidity is governed by the amount of moisture in the air and in its relation with collections and buildings, it is directly linked to temperature. Most insect pests require damp environments. High relative humidity encourages mould growth which in turn will provide food for certain pest species, but some pests, such as biscuit beetles, will live in lower humidities 40% e.g. if there is sufficient starch in their diet. Drywood termites will also survive drier conditions. Many pests which attack books will also live in dirt and debris which accumulates in inaccessible places in buildings. Clumps of fluff which are comprised of human hair, skin, and other organic debris, provide the food source for moths and carpet beetle larvae. They can then spread into collections. Good housekeeping is therefore vital to prevent insects becoming established within the building.

5 Buildings

Understanding the building is vital from the point of view of the environment and eliminating sources of pests. Even in buildings with good environmental control there can be pockets where insects may find more benign conditions. Many buildings are designed with little thought to accessibility of dead spaces. If these are not cleaned regularly they will provide reservoirs of food for pests. Some pests can get into buildings and collections from outside and proofing to prevent this is vital. Birds should be prevented from nesting and roosting in and around the building. Mice are more difficult to exclude, but well-designed proofing on doors, windows and ventilation ducts can reduce the risk of mice getting in. If they are established in a building then voids and dead spaces need to be identified and proofed to prevent mice from using them as living quarters.

6 Monitoring for pests

Early warning of pests is crucial to prevent damage to collections. Insect pests are small and when there are only a few they are difficult to find. Insect traps should be part of every pest management programme. Sticky blunder traps should be used as

basic monitoring devices for insects such as silverfish, booklice, ground beetles, carpet beetles and other crawling insects. Traps should be placed in a regular grid pattern against wall floor angles, preferably in corners where they will catch more wandering insects. The results from insect trapping can be used to plot the distribution of insects in a building and to determine changes in spread or increase in numbers. Some traps can be supplemented with pheromone attractants, but these are species specific e.g. for the webbing clothes moth. Insect traps are important but are not a substitute for regular inspection and checking. Insect pests prefer dark, undisturbed areas for harbourage. Collections should be examined for signs of recent pest attack such as fresh emergence holes and frass. It is important to distinguish between old damage and that which is active in order to decide whether remedial treatment is necessary.

7 Controlling pests in buildings

Targeted treatment using an approved insecticidal dust or spray can be very effective in reducing the numbers of insects in a building. However, insects often live in places where it is difficult to apply insecticides and will only come into contact with it when they wander across treated surfaces. Areas to target include wall/floor angles, cracks in woodwork, behind and under shelves /cabinets, and dead spaces such as ducts. Residual spray containing an insecticide, such as permethrin, can be applied to many surfaces and desiccant dusts can be very effective in dead spaces. Insecticides should never be applied directly to collection items. The use of aerosols or airborne sprays is not recommended unless you are trying to control flying insects. Such treatments achieve little control of most insect pests and can cause indiscriminate contamination of collections and the general environment.

8 Treating infested items

If you suspect that any items are infested, they should be isolated, usually in sealed polythene bags and/or a quarantine area. You should then identify the insect/s and decide on treatment, control and/or environmental modification actions. The choice of remedial treatment will depend upon the severity of the infestation, the type of material and the value of the items. Large scale treatment should only be carried out after taking the advice of a conservator or collections care specialist.

Low temperature

This will kill all stages of an insect's life-cycle and is now used by many libraries, archives and museums to treat collections. Books should be sealed in polythene and exposed to temperatures of -30°C for three days or -18°C for one to two weeks. Books should not be removed from the bag until they have returned to room temperature and there is no risk of condensation. Some large institutions use walk-in freezers or freezer chambers. This treatment is unsuitable for fragile items such as illuminated manuscripts.

Elevated temperature

All pest insects are killed at temperatures above 50°C. Books can be treated in 24 hours, without bagging, in a special Thermo Lignum™ humidity-controlled chamber at 52°C. This treatment is unsuitable for heat-sensitive material such as photographs and plastics.

Nitrogen anoxia

The treatment involves placing the books in a nitrogen atmosphere to kill the insects by depriving them of oxygen. It is effective only at nitrogen concentrations of greater than 99.7%. Long exposure times of 4 to 5 weeks are needed at lower temperatures of 15-20°C, although at 25-30°C, insects may be killed in 1-2 weeks. Treatment must be carried out in specially constructed chambers or enclosures made from a barrier film that has low oxygen permeability. The nitrogen usually needs to be humidified, and the oxygen levels carefully monitored and controlled using an oxygen meter. Treatment can also be carried out in smaller enclosures using a nitrogen generator.

Oxygen scavengers

Smaller objects such as individual books can be sealed in barrier film bags with an oxygen scavenger such as Ageless™ or ZerO2™. These products contain chemicals that react with the oxygen and remove it from the atmosphere in the bag. The procedure is very simple to use but is only really practical for small scale treatments.

9 Prevention is better than cure: setting up an IPM programme

Integrated pest management can be used in all types of collection, whether large or small. To prevent pests attacking small collections:

- Check collections regularly for signs of pests
- Use pest traps in the area
- Keep the books (and rooms where they are kept) clean
- Avoid keeping books in damp or humid areas.

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 collection in achievable steps. A suggested plan of action is as follows:

Survey the situation

- Obtain a plan of the building or make sketches.
- Carry out a preliminary survey to identify pest access points, high-risk areas and collections. Record this on the plan.
- Place monitoring traps.
- Plan a detailed inspection schedule for all areas.

Develop IPM procedures

- Check cleaning schedules and modify if necessary.
- Review any existing pest control contracts.
- Examine the pattern of movement of books in and out of the library.
- Establish a quarantine strategy for incoming books, if one is not in place. Document any action taken.
- Explain to key staff the objectives of IPM and encourage their co-operation.
- 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.
- Re-evaluate the IPM programme annually.

It is important to consider the overall costs relating to caring for paper-based collections. An IPM programme will prevent neglect and resulting deterioration of items, and consequently avoid the need for increased expenditure on remedial conservation and treatments.

10 Online resources and additional reading

Insect pests in historic houses (poster)

www.english-heritage.org.uk/publications/insect-pests-historic-houses-poster

Integrated pest management: a guide for museums, libraries and archives

www.aboutrestoration.eu/text/integratedpestmanagement.pdf

What's eating your collection?

www.whatseatingyourcollection.com

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Preservation guidance booklets

The following booklets can be downloaded free of charge at www.bl.uk/blpac/publicationsleaf.html.

Free printed copies are also available.

Basic preservation for library and archive collections

Building blocks for a preservation policy

Cleaning books and documents

Damaged books

Guidance for exhibiting library and archive materials

Managing the digitisation of library and archive materials

Managing the library and archive environment

Managing the preservation of library and archive collections in historic buildings

Packing and moving library and archive collections

Photocopying of library and archive materials

Preparing funding applications for preservation and conservation projects

Prevention and treatment of mould outbreaks in collections

Preservation of photographic material

Specifying library and archive storage

Understanding and caring for bookbindings

Using library and archive materials

The Preservation Advisory Centre promotes the benefit of good preservation practice and provides support in the form of information services, training and preservation management tools.

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