ExpoTime!

The international magazine for museum professionals

Double issue
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Introduction to some museum pests

Certain insects can cause damage to objects made of organic materials in museums, collections and churches. This damage always involves a loss of substance; it is irreversible and hence particularly feared by conservators. The damage presents itself in very different ways: Silverfish or so-called paperfish (*Lepisma saccharina / Ctenolepisma longicaudatum*) can literally graze off the surfaces of photographs or prints, but they can also eat through material.

"Grazed" surface on the upper cover of a book, caused by silverfish. Photo: Panko Traps

Wood-destroying insects such as the furniture beetle *(Anobium punctatum*) or the powderpost beetle (*Lyctus brunneus*) can turn wood into dust if they are allowed to pursue their natural purpose undisturbed. The powderpost beetle is considered to be extremely heat resistant; therefore, it was the ideal candidate for a new study that has re-examined the relationships between lethal temperature and exposure time in a number of museum pests and which is presented in the lower part of this paper.

The longhorn beetle (*Hylotrupes bajulus*) is very rare in museum collections and storage facilities. West Indian Drywood termites (*Cryptotermes brevis*) have been in-

Historic woolen shoes almost completely destroyed by the larvae of the clothes moth. Photo: ICM Europe

Drastic loss of substance by Anobium punctatum infestation, parts of a polychrome procession throne, 19th cent. Photo: ICM Europe

troduced into collections, but of course do not occur naturally in Europe.

There is another group of museum pests that specialize in the utilization of keratin: the clothes moth for example (*Tineola bisselliella* and *Tinea pellionella*), or the carpet beetle (various *Anthrenus* species) are very common in museums and depots and can cause great damage. Keratin is a protein found in hair, fur, feathers, wool and horn. Chitin can also be eaten and metabolized by some insects. Natural history, entomological, ethnological and textile collections are by their nature frequently affected by these species.

Insect pests always find access to collections

A completely pest-free museum collection or depot is, in most cases, an illusion.

In most buildings, potential gateways for pests are simply too numerous and complex to permanently control or block. Especially in older buildings there are leaks, poorly closing windows, cracks in the masonry, leaking doors, downpipes, chimneys and so forth. But the insects find their way into the depot also in another way: namely in or on the objects, in transport boxes and pallets (think Trojan horse).

A box of infested spices and plant parts can be the trigger for a widespread infestation with tobacco beetle (*Lasioderma serricorne)*; a clothes moth infestation introduced undetected in a costume can be the cause of years of hassle and sometimes dramatic damage. The powderpost beetle sometimes lives in the wood of art shipping crates and can spread from there. The longhorn beetle which, as already mentioned, is fortunately very rare in collections, attacks exclusively conifer wood (spruce, fir, or pine), and can enter the collection facilities via wooden pallets, which are often made of just such conifer wood.

Increasing art lending traffic inevitably brings with it the introduction and distribution of insect pests worldwide. Museum entomologists, such as David Pinniger, have observed over decades that new insect species suddenly appear in regions and museums where they did not previously exist. Climate change is adding to that and will speed up the spread of more species. (You can see and hear a presentation by David Pinniger "New Pests – New Challenges" on this very topic at https://www.icm.works/en/icm-and-sothebys-institute-of-art-new-york-recording-of-joint-webinar-now-available/ starting at ca. 05:10).

An art warehouse or museum depository can provide ideal hiding places

Collection depots can provide ideal shelter and hiding places for insects. The British, in their pragmatic approach, who have always been pioneers in the field of IPM (Integrated Pest Management), advise "good housekeeping". What is meant by this is above all orderliness and hygiene. Access to all objects, boxes and shelves must be guaranteed. You must always be able to reach objects everywhere, ideally you are able to move them around, you must be able to clean everywhere, even under shelves and pallets. Collection warehouses tend to be filled up more and more, thus obstructing crucial access points. In doing so, the collection is not doing itself any favours – but the insects appreciate it.

In a well-planned and modern IPM concept, order and hygiene are of course not enough. The climate must be monitored; some pests thrive particularly well at high relative humidity (so does mould!). Another essential IPM component are insect traps, which must be set up and which primarily provide information on whether you have any insects in the collection at all, and if so, which ones. With the help of such IPM strategies, the incidence of insects can be significantly reduced.

If you find insects in your collection, it is not necessarily a disaster. Keeping calm is the top priority. Don't panic! However, good advice is essential (for example, you can get good advice from Stephan Biebl, https://museumsschaedlinge.de/ueber-uns/; Bill Landsberger, Rathgen Institute Berlin; Pacal Querner, http://www.ipm-museen.at/; David Pinniger, reachable through the author).

Treatment options

If one detects or suspects an infestation, several methods of control are available:
- Freezing the objects
- Heating with humidity-controlled warm air
- Anoxic treatment / oxygen deprivation
- Use of beneficial insects, such as parasitoid wasps
- Use of poison

All methods have their advantages and disadvantages. However, the use of poison should be considered an anachronism and it is, for obvious reasons, often no longer accepted. Moreover, the serious consequences of biocide contamination in museums and collections are becoming increasingly clear. The contaminants not only endanger the health of the people who handle the objects or work in the same rooms where the objects are stored. Many of the biocides also damage the objects.

The humidity-controlled warm air process

The main focus here is on the humidity-regulated warm air method. The method has been around for over 30 years. It was originally developed for the treatment of furniture and wooden objects. Today, for example at ICM London or ICM Brussels, it is also used to treat also the finest and most valuable panel and canvas paintings (in London, for example, paintings by Pontormo, Botticelli and Arcimboldo have been treated). Contemporary installations are being treated increasingly. It is by no means the case that primarily old or "antique" objects that are infested.

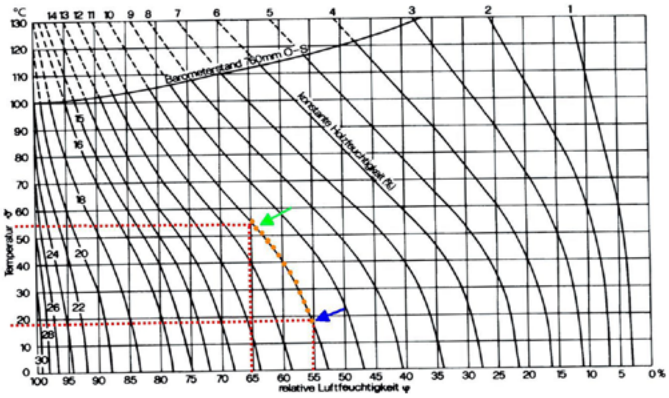
TATE, the V&A, the National Gallery and many other museums, galleries and private collectors have had their objects treated with humidity-controlled warm air for years, sometimes decades.

The process is based mainly on two factors:
1. insects die when it gets too warm
2. precise control of the relative humidity in the treatment chamber prevents dimensional changes in the object

The humidity-controlled warm air process is fundamentally different from the conventional hot-air process, which is used to rid roof trusses or entire buildings of insect pests. In the hot air process, the blown-in air is not humidified, or only to a very small extent. Hence the air is dry, and the temperature is high (70-100 °C). Works of art and collection objects must not be treated with conventional hot air.

In contrast, in the humidity-regulated warm air process, the temperatures are much lower (normally 46-52°C) and the relative humidity is controlled. The humidity control is of utmost importance.

In the insulated climatic chambers, the air is warmed up very slowly, kept at the target temperature for a certain time, and then cooled down again very slowly. During the whole process, the relative humidity is humidified exactly according to the Keylwerth's diagram. Thus, there is little to no moisture exchange between the objects and the surrounding air - and therefore minimal movement in the object.



The Keylwerth diagram illustrates the relationship between temperature, relative humidity and the Equilibrium Moisture Content (EMC) in wood. Raw diagram from: https//www.irbnet.de/daten/rswb/13029006903.pdf, p. 13)

A simple explanation of Keylwerth diagram table above: If a piece of wood is heated from 18 °C (blue arrow) to 55 °C (green arrow), and at the same time the relative humidity is increased from 55 percent (blue arrow) to 65 percent (green arrow), the EMC (equilibrium moisture content) remains unchanged. The wood does not shrink when warmed up, nor does it swell when cooled down. These laws are absolutely essential for the process.

In this context Dr. Nigel Blades, Preventive Conservation Advisor at the British National Trust, in cooperation with Polish scientists, has made an interesting experiment

The 40 m³ ICM chamber in Brussels. Treatment of two insect-infested Flemish cabinets, wood veneered with tortoiseshell, inlaid and solid ivory, fire-gilded brass fittings. Next to it two painted sculptures. Photo: ICM Europe, Kampenhout

with the humidity-regulated warm air process. Title of the work: “Acoustic emission monitoring of furniture response during humidity regulated warm air treatment”. Special microphones were attached to a number of objects (including the Gole Table, c.1671, http://www.nationaltrustcollections.org.uk/object/129518 and the two Torchères http://www.nationaltrustcollections.org.uk/results?Maker=Pierre+Gole+(c.1620-1684)). Acoustic emission was recorded throughout the course of treatment. The data provides insight into movement activity during treatment. The project was presented at the 2020 Pest Odyssey Conference and can be accessed on YouTube: https://www.youtube.com/watch?v=VfbC0zlg3Ic, the presentation starts at approximately 1:53:50.

Inlaid and composite surface furniture can also be treated. Furniture in Boulle technique have already been treated in the ICM London chamber. Photo: ICM Europe

New study on lethal temperatures of four museum pests ICM, together with *Materialprüfungsanstalt Eberswalde* MPA (http://www.mpaew.de/) and *Senckenberg Deutsches Entomologisches Institut* (SDEI) Müncheberg (https://www.senckenberg.de/de/institute/sdei/), conducted several experimental trials between February and May 2021 to verify the lethal temperatures for some typical museum pests. The results of the study were presented at the largest professional conference of its kind, the Pest Odyssey Conference, on Sept. 21, 2021.

Results of the study were presented at the Pest Odyssey Conference on 9/21/2021. Already at 46 °C, which was held for six hours, all insect samples (eggs, larvae, adults) were 100 percent dead. The table below lists the results of the tests. The new findings open up new possibilities for treatment.

On the other hand, certain materials may not be treated with heat at all. These include parchment. Photo negatives or early plastic should also be treated in a different way. Untanned, already decomposing leather should be treated at temperatures well below 50 °C.

Part of the experimental setup for lethal temperature determination for *Anobium punctatum*, *Lyctus brunneus*, *Ctenolepisma longicaudatum* and *Tineola bisseliella*.
Left: Heating cabinet with exsiccator. Right: the insect samples in plastic containers. Photo: ICM Europe

Number of surviving insects		6	0	0	0	0	0	0	0	0	0	>168
		4 h	**6h**	**8 h**	**10 h**	**12 h**	**16 h**	**24 h**	**32 h**	**40 h**	**48 h**	**Contr.**
L. brunneus	adults	0 (10)	0 (10)	0 (5)	0 (10)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	15 (15)
	larvae	6 (10)	0 (10)	0 (5)	0 (10)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	15 (15)
	eggs	0 (2 ba.)	0 (2 ba.)	0 (1 ba.)	0 (2 ba.)	0 (1 ba.)	0 (2 ba.)	0 (1 ba.)	0 (1 ba.)	0 (1 ba.)	0 (1 ba.)	hatched
A. punctatum	adults	0 (10)	0 (10)	0 (5)	0 (10)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	12 (15)
	larvae	0 (10)	0 (10)	0 (5)	0 (10)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	15 (15)
	eggs	0 (>69)	0 (>35)	0 (>30)	0 (>92)	0 (>17)	0 (38)	0 (>9)	0 (>7)	0 (>11)	0 (>175)	>22 (>123)
C. longicauda-tum	adults	0 (8)	0 (8)	0 (3)	0 (8)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	13 (13)
	larvae	0 (8)	0 (8)	0 (3)	0 (8)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	11 (13)
	eggs	0 (2 ba.)	0 (2 ba.)	0 (1 ba.)	0 (2 ba.)	0 (1 ba.)	0 (2 ba.)	0 (1 ba.)	0 (1 ba.)	0 (1 ba.)	0 (1 ba.)	0 (3 ba.)
T. bisselliella	adults	0 (10)	0 (10)	0 (5)	0 (10)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	13 (15)
	larvae	0 (10)	0 (10)	0 (5)	0 (10)	0 (5)	0 (10)	0 (5)	0 (5)	0 (5)	0 (5)	15 (15)
	eggs	0 (2 ba.)	0 (2 ba.)	0 (1 ba.)	0 (2 ba.)	0 (1 ba.)	0 (2 ba.)	0 (1 ba.)	0 (1 ba.)	0 (1 ba.)	0 (1 ba.)	37 (3 ba.)

Killing efficiency of different exposure times at 46 °C on four different insect pest species. Given are the numbers of surviving adults, larvae or eggs, respectively, with the number of tested individuals in parenthesis. For eggs, uncounted egg batches (abbreviated: ba.) were used for three of the species. The control groups were kept in parallel to the treatments at suitable conditions. © ICM Europe

A major advantage of the warm air method is the speed of the treatment cycle. While a treatment with anoxia / oxygen deprivation can take 2 to 5 weeks, or even more, and freezing of objects must be maintained up to 14 days, depending on the temperature (3 days at -30 °C, 7 days at -25 °C, at least 14 days at -18 °C), a treatment cycle with humidity controlled warm air is usually successfully completed after 16-24 h.

It is important to understand the paramount importance of the humidity control according to the Keylwerth's diagram, then it becomes clear why there are no changes in the object even though it is warmed up. The temperature itself plays – within certain limits – an absolutely subordinate role.

Successor of Pieter Coecke van Aelst, end of 16th cent. On the right, the so-called reference block indicating the core temperature. Climate chamber, ICM Kamphout. Photo: ICM Europe

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