

Diapositive
1

INTEGRATED PEST MANAGEMENT IN ARCHIVES

*You say you want a revolution,
well, you know...
We all want to change the world*

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The Beatles Songbook

- Insects:
 - *The Long and Winding Road*
- Mold:
 - *Every Little Thing*
- Pest Management in Practice
 - *Yesterday*
 - *Revolution*

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Insects

1. Who are they?
2. Development cycle

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Who are they?

- **Very ancient biological group**
 - Some species have been on Earth for more than 300 million years!
- **Very large biological group**
 - Insects constitute the most important biological group : 950 000 species are known today, while several disappear every year ...

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Who are they?

- **Insects belong to the arthropods group**
 - Adults present the following characteristics (although not necessarily all simultaneously in a single species):
 - Body in three parts: head, thorax, abdomen;
 - Three pairs of legs;
 - Two pairs of wings;
 - One pair of antennae of the head;
 - Composite eyes.

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Who are they?

- **Physiological functions of insects:**
 - External skeleton;
 - Abdominal nervous system;
 - Respiratory system disseminated on the entire body;
 - Dorsal circulatory system;
 - Digestive system;
 - Reproductive system.

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Development cycle

- **There are two different development cycles, which contribute to characterize insects species :**
 - **Incomplete metamorphosis:**
 - **The larva resembles the adult insect.** Smaller in size, it outgrows a series of skeletons by successive mutations. The larva distinguishes itself from the adult by the absence of wings, as well as a reproductive system.

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Development cycle

- **Complete metamorphosis:**
 - **The larva is morphologically different from the adult.** It mutates by going through several successive intermediate states: egg, larva, pupa, then nymph.

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Development cycle

- **Effects of the type of development cycle:**
 - On cultural heritage objects and documents, the major damages are induced by **larvae**.
 - The nature of the development cycle also has an effect on curative treatments. As a general rule, **eggs and larvae are more resistant** to an unfavorable environment than adults.

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Microorganisms

1. Who are they?
2. Development cycle

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Who are they?

- The various types of microorganisms that can affect cultural heritage objects and documents are:
 - Fungi (mold and mildew) (120 000 species);
 - Algae (30 000 species) and moss;
 - Lichens (18 000 species);
 - Viruses and bacteria.

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Who are they?

- On archival documents, infestations are most frequently due to mold.
 - Hence, the following information will specifically refer to the development cycle of this type of microorganisms.
- However, one may be confronted to bacterial or viral infestations, for instance after a flood involving contaminated waters.

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Who are they?

- The mold that develops on archival documents most frequently have more than one cell (unlike, for instance, yeast).
- **This type of mold is characterized by threads**, called «hyphae», which constitute the part that enables the microorganism to feed on the nutritive substrate.

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Development cycle

- Mold extracts the nutrients necessary for its development from the environment. **Each species develops on a specific substrate**, depending on the enzymes produced:
 - Production of cellulase: development on cellulosic materials such as paper and fabric ;
 - Production of collagenase: development on collagenic materials such as leather and parchment.

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Development cycle

- **Hyphae spread on the substrate from a spore, which has germinated.**
- Spores are disseminated by winds, insects, ourselves, or by any object or document on which a mold colony had previously developed.

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Development cycle

- The ends of hyphae are highly permeable.
Therefore, it is at the periphery of the mycelium that nutrition occurs:
 - Acidic substances and enzymes are produced and combined with water available in the substrate;
 - More simple molecules, which can be assimilated by the microorganism, are in return retrieved from the substrate.

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Development cycle

- **The spore is a dehydrated cell** surrounded by a thick membrane. The spore's metabolism can block itself until environmental conditions become favorable to the fruition process:
 - **Spores can stay in a non-active state** for long periods of time (several years!).
 - For certain types of spores, **fruition follows an activation phase.**

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Development cycle

- When environmental conditions become adequate, the spore is activated, then fruition occurs and the hyphae start to grow... only to generate new spores.
 - **The infestation is «active» when the mycelium is in growth.**
 - Like spores, hyphae can remain still for some time; the infestation is then said to be «non active ».

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Development cycle

- **How long does it take for a spore to start developing?**
 - If the spore is activated by favorable environmental factors, it only needs a few hours before it can undergo the fruition process.
 - But... even under a microscope, there is no visible difference between a non-active spore and a spore which has been activated, and is ready to germinate. Caution is thus imperative!

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Development factors

NUTRITIVE ELEMENTS	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• Are necessary for development• Are found in buildings and archival documents	

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Nutritive elements

- Remember that dust is an important source of degradation of archival documents, because:
 - It is **highly hygroscopic**;
 - It is **extremely rich in biological nutrients**;
 - It is abrasive and can scratch sensitive coatings;
 - It can catalyze chemical reactions (such as the oxidation of paper);
 - It can lessen the legibility of documents and artworks on paper or parchment, and also...
 - It is depressing!

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Nutritive elements

- Mold develops more easily on a substrate that has already been altered, either by another microorganism or by insects.
- In optimum conditions, the growth rate of hyphae can attain 80 microns per minute.

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Development factors

TEMPERATURE	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• Adapt to a wide range of temperatures• Generally develop faster in warm environments	

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Temperature

- In our climates, the optimum temperature for most insects and mold species that are found in archives ranges **between 22 and 29 °C.**
- However, some species will develop in less temperate conditions:
 - for mold, from 0 to 40 °C.

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Development factors

HUMIDITY	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• Require a certain amount of water available in the environment• Develop faster in humid environments	

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Humidity

- **Water is available in the air** (in the form of vapor) **and/or in the nutritive substrate** (internal humidity level).
 - It is generally said that mold will not develop if relative humidity is lower than 65%.
 - However, fruiting can occur in seemingly dryer environments, because of micro-climatic conditions or if the internal humidity level of the substrate is sufficiently high.

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Development factors

LIGHT	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• Prefer dark locations	<ul style="list-style-type: none">• Can develop in either light or dark locations

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Light

- Some insect species move to strongly lit locations during the mating period.
 - However, most insects which are found in archives tend to spend most of their life in dark and humid locations.

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Light

- Nutritive elements and organic wastes are kept near the spore. **These by-products are colored.**
 - Mold does not perform photosynthesis: it can therefore develop without light.
 - However, less colored products are generated when growth occurs in the dark.

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Development factors

VIBRATIONS / AIR MOVEMENT	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• Prefer locations without vibrations	<ul style="list-style-type: none">• Need still air for the spores to fall, deposit and attach to substrate in order to develop

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Development factors

OXYGEN	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• Require a certain amount of oxygen to be available in the environment	

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Development factors

pH OF SUBSTRATE	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• Important regarding the ecosystem (acid rains)	<ul style="list-style-type: none">• High tolerance to wide range of pH values• Optimal growth around pH = 5

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Development factors

ENVIRONMENTAL CONDITIONS	
<i>Insects</i>	<i>Mold</i>
<ul style="list-style-type: none">• If a few factors are favorable, insects will develop	<ul style="list-style-type: none">• Requires simultaneous factors to develop:<ul style="list-style-type: none">- Water available- Adequate temperature- Slow air circulation- Oxygen- Specific pH of substrate

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Integrated Pest Management

- According to David Pinniger, IPM is...
 - Avoiding pests
 - Preventing pests
 - Recognizing pests
 - Assessing the pest problem
 - Solving the pest problem
 - Assessing IPM procedures

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Avoiding pests

- **First rule: keep them away!**
 - In order to keep insects away from a building, know your environment well
 - Example from a Tibetan monastery
 - Example from a Ugandan library

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Avoiding pests

- **In your climate, a few tips...**
 - Ensure proper drainage around the building
 - Plant vegetation away from the outside walls
 - Look for non attractive or even repulsive plant species
 - Avoid placing lamps directly on outside walls, and especially near doors and windows
 - Put trash far away from the building

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Preventing pests

- **Second rule: make them unhappy!**
 - In order to prevent pests from settling in your environment, know their habits well
 - Example from a Tibetan monastery
 - Example from a Ugandan library

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Preventing pests

- **In your climate, a few tips...**
 - Repair all cracks in the walls
 - Do not let doors and windows open
 - Ensure that doors and windows close hermetically
 - Ensure that wire mesh on doors and windows is not broken

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Preventing pests

- **And also...**
 - Maintain cleanliness throughout the building
 - Maintain relative humidity at even, medium levels (around 50% if possible)
 - Ensure constant air circulation
 - If technical equipment allows it, maintain a slight overpressure in the building

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Recognizing pests

- **Third rule: know when they are around!**
 - In order to eradicate pests from your environment, know all their disguises well
 - Souvenir from a trip to Indonesia
 - Example from a Ugandan library

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Recognizing pests

- **Where should you check first?**
 - Most humid areas
 - Less often visited areas
 - Areas where prevention systems have proven to be defective (slashed wire mesh, etc.)
as well as
 - Areas where the holdings most sensitive to biological infestations are kept

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Assessing the pest problem

- **Fourth, a question: when do we start considering there is a pest problem?**
 - Ideally, a quantitative approach to the pest problem should help set up and manage an adequate eradication strategy
 - French dilemmas

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Assessing the pest problem

- **How frequently should inspections occur in the building?**
 - Awareness to signs of biological infestations is a continuous process, which can be greatly enhanced by **trapping**
 - Minimally, the building should be inspected twice a year: during springtime and in the fall

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Assessing the pest problem

- **Signs of alert in the building**
 - Spider webs!
 - Dead insects and fragments of insects (wings, etc.);
 - Exuviae and cocoons;
 - Holes and galleries in wood, heaps or trails of saw dust around wooden structures and objects.

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Assessing the pest problem

- **What are the most sensitive holdings?**
 - In priority
 - Incoming archival holdings
 - Previously infested holdings
 - Holdings with a high internal humidity level
 - Holdings containing protein-based materials
 - Yet, as a general rule
 - All holdings should be periodically inspected

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Assessing the pest problem

- **How frequently should inspections occur?**
 - On holdings which have never been infested?
 - On holdings which have been previously infested?
 - As often as possible, depending on staff availability!
 - Minimally, holdings should be inspected twice a year: during springtime and in the fall

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Assessing the pest problem

- **How many housings must we inspect to make sure there is no infestation?**
 - According to the laws of statistics, at any given moment in time, a sample of 400 randomly selected units will give results that are correct with a 95% range of certainty.

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Assessing the pest problem

- **Can we apply this rule to dynamic systems, such as biological infestations?**
 - Let's try!
 - 200 randomly selected boxes inspected each spring and fall
 - 5 minutes per box: 16 man-hours

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Assessing the pest problem

- **How should holdings be inspected?**
 - For insects and mold
 - Visual examination

 - If mold is suspected
 - **Laboratory testing**

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Solving the pest problem

- **Choices: choosing an eradication strategy**
 - Mold
 - Cleaning and disinfecting the building
 - Chemical treatment

 - Insects
 - Freezing and heat treatment
 - Inert atmospheres
 - Chemical treatment

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Solving a mold problem

- **How often should the building be cleaned?**
 - As often as possible, by trained staff which will inform the Archives' Director if fungal spots are noticed during cleaning.

 - Of course, internal cleaning of dry pipes and changing of filters of HVAC systems are also compulsory.

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Solving a mold problem

- **With which products should the building be cleaned?**
 - Products should be selected for their antiseptic, **antifungal** and/or **sporicidal** characteristics.
 - Of course, safety for staff use (protective clothing, etc.) should be considered.

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Solving a mold problem

- **Choices, still:**
 - For mold, should we consider chemical treatments to be “overkill”?
 - French and Canadian research

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Solving an insect problem

- **How do curative eradication methods work?**
 - The most promising methods function by altering the respiratory or the nervous system:
 - Asphyxia, or weakening of the insect by modifying the atmospheric oxygen content;
 - Molecular alteration:
 - By modifying the temperature;
 - By using gaseous or liquid chemicals.

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Indeed... an attitude problem?

- **Choices, again:**
 - For insects, can we adopt a “loss and profit” strategy?
 - Example for an archives in French Guyana
 - Example for a Tibetan monastery

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Songs of wisdom?!

Jai Guru Deva, Om...

Nothing's gonna change my world

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In the end...

- **Mold will grow on your archives...**

Eight days a week
- **Insects will still be eating away at paper and parchment...**

When I'm sixty-four

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• **So if you don't want to be crying for...**
Help!

• **A change of attitude is needed... and**
Here comes the sun

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• **I am personally confident that with IPM,**
there shall be no need for a...
Revolution

• **Because...**
*« If you are talking about destruction,
brother you can count me out! »*

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Let it bee.

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