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Insect Pest Control using low temperatures (not deep freezing)

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Introduction
In some areas of Canada, it used to be the farmers' practice to open the doors of the grain storage barns in winter and let the freezing cold air blow through. The result was that insect pests were killed, but the grain still remained viable to be planted and to grow the following season. This is the basis of using very low temperatures for insect pest control in museums. Conversely, we know that many insects happily survive very cold winters to emerge in the subsequent spring to live and breed. This phenomenon goes some way to explain why some museum low temperature treatments fail.

Low temperature insecticidal treatments on museum objects, should achieve 100% mortality on all insect stages – eggs, larvae, pupae and adults, without damage to the affected objects.

Low temperatures and insects
Insects can adapt to lowering temperatures in a number of ways. They can find warmer niches deep inside materials such as in wood, where the very low temperatures do not penetrate; they can form anti-freeze chemicals that stop their body fluids from freezing; and in some circumstances some insects can survive some freezing of body tissues.

In almost all known circumstances, avoidance of low temperature problems involves a slow adaption as the weather cools towards winter. As the weather cools, insects tolerant to cold, adapt by developing anti-freeze chemicals such as glycerol in their systems and slowing down their metabolism to a 'tick over' minimum state.

Insects are killed by low temperatures when the rate of cooling and the degree of cooling does not allow the self-defence mechanisms to develop. Therefore, fast cooling and low temperatures will have a greater tendency to kill all stages than slow cooling.

Low temperatures and objects
Organic materials that may be vulnerable to insect and other biological attack can contain moisture of two different types. 'Free' or liquid water, and bound water where the molecules are securely 'bound' to the material. 'Free' water is found in living material and in freshly killed or felled materials in normal conditions, this liquid water will dry out (as in seasoning of timber) until the material is dry. Further drying will occur with the loss of the bound water until an equilibrium is reached with the relative humidity (RH) of the surrounding air. Changes in RH causes organic materials to absorb or lose 'bound' moisture and correspondingly to expand or contract, often damagingly.

Low temperatures can damage objects in a number of ways, including:

- At low temperatures (well below 0^{o}C), free water can freeze, and the ice crystals formed can damage the material (as anyone who has tried to deep freeze soft fruit will know). Bound water does not freeze until very low temperatures and so ice formation is not a problem unless the object is damp for some reason.

- Many organic materials have a glass transition temperature, below which they lose suppleness and flexibility and become rigid, brittle materials. When this is combined with contraction due to the lowering of the temperature, fractures may occur. Thick paint layers (impasto) have been known to crack when cooled from 25^{o}C to -30^{o}C. Similarly, brittle materials such as ivory, could also be damaged.

- Condensation on the object on cooling or in the subsequent warming-up process can cause water related damage such as staining, dye migration and corrosion of metals. To prevent this, objects should be wrapped and sealed in plastic sheeting, and as much air removed as feasible.

Absorbent material such as tissue paper, cotton fabric and conditioned silica gel can be added to preferentially absorb any high RH's and condensed water.

Recommendations

The recommended procedure for using low temperatures to kill insect pests is as follows:

(This summary is a general guide for freezing objects such as textiles, paper and wood. Where there is concern about the fragility of an object, advice should be sought from a conservator about the suitability of freezing. Another method, such as anoxia may be more appropriate.)

Freezer temperatures and exposures needed;

- -18°C to -20°C. Objects can be treated with 10 to 14 days exposure. This is the temperature of a standard domestic type deep freeze.
- -30°C. Objects need 3 days exposure.

It can take at least 24 hours for the centre of dense objects, such as rolled textiles, to reach the target temperature. It is advisable to place a temperature sensor in the centre of very dense objects to ensure that target temperatures have been reached.

Procedure

- Objects should be wrapped in acid-free tissue.
- As a precaution, wrap any metal components in additional acid-free tissue.
- They should then be wrapped in plastic sheeting. If possible, avoid including a large amount of air in the bag.
- Large voids, such as between chair legs etc., should be filled with buffering material such as crumpled paper or cloth.
- If the object is fragile or an awkward shape, then it can be placed in a tray or an archive box which can then be wrapped in plastic sheeting.
- Seal the bag with tape, or a tie, and label it with the object's description, date and name of person responsible for the object.
- Place the object carefully in the freezer.
- Do not pack objects too tightly and ensure there is an air space around the sides of the freezer. Baskets can be used if they are supplied.
- Place a wood or foam spacer on the floor of the freezer before loading to ensure that there is an air space under objects to allow the fold air to circulate.
- Expose objects for the appropriate time.
- Remove objects carefully, many materials will be very brittle at low temperatures.
- Place objects on racking or on the floor, and allow them to recover to room temperature for a least 24 hours before they are unwrapped.
- Very dense objects should be left for at least 48 hours.

- Objects may be left wrapped for some weeks if there is a risk of them becoming re-infested.
- After recovery and unwrapping, the objects should be cleaned to remove dead insects and signs of infestation such as frass and webbing.
- The treatment of each object should then be documented.

IMPORTANT NOTE:

- If a -30^{o}C freezer is used, then staff must use freezer gloves and avoid contact with surfaces to prevent freezer burn.
- If freezers are running continuously, objects can be placed immediately. If they are switched on for each treatment, they should be operating for 24 hours before objects are introduced.
- Auto-defrost freezers should not be used.

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