International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG(USA) Volume 6, Issue 9 -2019

Review Article

DOI: http://dx.doi.org/10.22192/ijarbs.2019.06.09.016

Management of pests risks in museums: A review

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Abstract

Pests in a Museum, Library or Archive environment can lead serious damage to highly precious and irreplaceable materials. India is one of the leading countries which possess the largest number of natural history collections. As we all know that the organic materials get easily susceptible to deterioration by biodeteriogens like insects, fungi, algae and rodents etc whereas the composition of natural history collections are organic in nature as well. To include the pests and integrated pest management in the bigger framework of risk management, we need to be able to assess the risk of pests to collections. Risk assessment begins with developing a 'risk scenario' that describes what is expected to happen. It describes how a threat comes from a particular source, how it follows a pathway from the source to particular objects, how it affects the objects and what the effect will be in terms of loss of value. This paper introduces the insect scenario scheme, a tool that sketches possible scenarios for insect pests in collections. Furthermore, this paper also aims to focus the next step, regarding the negative effects of some synthetic chemicals on staff, objects and environment. Nowadays there is an increasing pressure to move away from persistent and toxic pesticides to some natural and indigenous method of pest control. Therefore, it is an utmost need for integrating the traditional and natural methods of pest control in the Integrated Pest Management (IPM) of museums.

Keywords: Biodeteriogens; Deterioration; Indigenous method; Integrated Pest Management(IPM); Natural history collection; Risk management.

1. Introduction

Museum organic collections like stuffed mammals, bird skins, insects and herbarium specimens are frequently damaged by insects and the risk of infestation is well known. While there are also few insects found in some museum collections which may not incite concerns, but fostering certain environmental conditions, allow pests to progress from grazing and perforation to complete destruction of museum's highly valuable collections. [1, 2]The majority of facilities dealt with pests in a reactive way, such as fumigating objects to kill the pests after the infestation has occurred or monthly spraying in museums done. [3, 4]

Such reactive approaches to pest control typically involve the application of some type of pesticide to control or prevent infestations. Despite of routine applications of pesticides in a museum may not be sufficient to prevent complete infestation. We get accustomed to such type of approach through tradition. Even though pesticide chemical applications directly on the objects may damage or destroy museum collections and produce undesirable residues. [5,6]. In addition, certain methods involving the use of non-chemical controls such as heating, freezing, anoxia, N_2 or CO_2 treatments may also harm the materials if they are not used with the proper care of objects. Therefore, a more preventive and proactive

approach to this problem is needed to control and prevent infestations and reduce the possibility of damage to materials. Beside the above problems, other factors like hazards to humans, animals and the environment should also be considered simultaneously.

To prevent damage by the pests and their infestation from a museum, a holistic concept should be properly applied. An Insect Pest Management (IPM) programme should be developed according to the needs of the building and the collections it owns, as well as the variety of activities that take place within the building. The programme should be considered as a process of evolution rather than a revolution. It should encourage participation by all those working on the site with the full involvement of staff at all levels. In order to develop an effective IPM strategy with above mentioned points it is also very important to understand and recognize the key elements of successful pest control such as avoiding pests, preventing pests, identifying pests, assessing the problems (based on inspection and trapping, and identifying the high-risk parts of the collection and building, life cycle of pests, especially insects), solving pest problems, and very important reviewing the IPM procedures [7].

Nowadays an increasing emphasis is being placed on environmental sensitivity and the reduction in use of traditional pesticides. Worker and public safety is also becoming a greater concern with the increasing likelihood of lawsuits and litigation over past exposures to potentially hazardous materials. Rather than decide to abandon all attempts to control the pests, less hazardous alternatives to the traditional methods should be considered [8].

2. What is Integrated Pest Management?

The point of departure of definition of IPM was given by the Food and Agriculture Organization of the United Nations (FAO) in 2013, and the United States Environment Protection Agency (USEPA) in 2012. Together they state the definition of IPM as, Integrated Pest Management *(IPM) is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize the risks to people, property, and the environment* [9, 10].

Another important definition of Integrated Pest Management (IPM) is defined as, *a process consisting of the balanced application of cultural, biological, and chemical procedures that are environmentally compatible, economically feasible, and socially acceptable to reduce pest populations to tolerable levels*. [11]

Integrated means that many strategies are used to avoid or solve a pest problem. These strategies come from different disciplines, such as from the agronomists and from the entomologists [12, 13]. Pests are unwanted organisms that are a nuisance to man or domestic animals, and can cause injury to humans, animals, plants, structures, and possessions as well. Whereas, management is the process of making decisions in a systematic way to keep pests from reaching intolerable levels. [14]. 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 [15]. The approach is one of using non-invasive methods to prevent or at least minimize the risk of pest infestation. The main principles of IPM are monitoring, discouraging pests, modifying the environment and targeting treatments that have been adapted for use with museums 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.

3. Need for IPM

The pesticides are health hazardous and long exposure to it can caused acute symptoms such as nausea, vomiting and breathing difficulty. It can also cause chronic effects such as seizures, skin and eye irritation and memory defects. Sometimes, many pesticides are carcinogens or suspected carcinogens in nature. [16]. So for the long term benefit of staff, researchers and visitors safety IPM can help to reduce the amount of pesticides used in the museums. Not only to the staff or users, pesticides can also cause following damages to the collection in long term. So the reduced or moderate use of pesticides will aid to lessen the risk of chemical deterioration to objects as well [17]. The damages which may occur in collections are mention below:

1. Deterioration of inorganic materials such as metal, stone etc.
2. Deterioration of organic materials such as skin and skin products, herbarium, wooden collections.
3. Color change of papers, textiles, inks and pigments.
4. Stain development from surface or due to humidity.

A well planned and executed IPM programme will not only prevent the problems in its initial stage but also it would make much more effective use of limited human and cash resources [18].

4. Classification of Museum Pests:

Biodeterioration is a product of the action of many biological agencies. Pest can be of any type or size, but their action on museum objects can lead to irreplaceable damage. The damage caused by pest can vary from organism to organism and from object to object. If we talk about insects, they are most notorious and destructive form of pest, which are causing damage to museum valuable objects. Whereas each insect may have different habitat, physiology, and attitude and therefore they cause damage in different ways. [19] There are much different type of pests that can affect the museum and its collection. According to their food and habitat [20], these insects can be categorized as following:-

1. Insect pests on skin and skin products
2. Insect pests on wooden collections
3. Insect pests on stored products
4. Insect pests in humid environment
5. General pests

4.1. Insect Pests on Skin and Skin products

A big group of insect pests found in museums are made up of animal skin and hides. Generally the skin and skin products insects are keratine and chitin feeding insects. [21]. Outside of buildings, they feed on dead animals, or live in nests of vertebrate or bird nests, etc. Inside of museums they feed on fur, feathers, animal skin, hair, bristles, animal wool, felt, silk, yarn, velvet, carpeting, insect specimens, parchment and vellum or stuffed animals, etc [22]. Dermestid beetles are one of the most important skin and skin products insect pest found in museums such as carpet beetles and varied carpet beetle. The most common beetles among them are the species of *Anthrenus verbasci* (varied carpet beetle).

For this kind of beetles not only museum objects can be a food source but also dead insects like flies accumulating under windows can attract them. Together with the webbing clothes moth, they are also found in dust where they find sufficient food. From these reservoirs of pests, new infestations may take place. So therefore, making regular cleaning is always an important part of modern IPM in museums.

4.2. Insect pests on Wooden Collections

The most common wood pests are the wood boring beetle and the dry wood termites. These pests are known to attack and damage the wooden objects. Wood Boaring Beetles (*Anobiid),* Furniture and Deathwatch Beetles *(Anobiides),* True Powderpost Beetles *(Lyctidae),* False Powderpost Beetles *(Bostrichidae),* Termites *(Isoptera)* etc, are the very harmful wood pests.

4.3. Insect pests on Stored Products

The most common stored products insects are cigarette beetles, drugstore beetles and carpet beetles. They are responsible for severe infestation in field of agriculture, such as in seeds, nuts, grains, spice, dried prawn, fishes and meat, etc hence they are also called as pantry pests. [23,24]. These pests are also responsible in attacking on protein rich materials like wool, fur, feathers, dead animals and horns as well. These pests are known to burrow into materials such as storage bins or storage cabinet, little used drawers etc [25-28].

4.4 Insects pests in Humid Environment

Moisture can damage not only to the building but also to the museum objects. Pests like *Psocoptera* to feed on the objects that are affected by mold. It is important for museums to keep their facilities and collection areas free from any dampness and immediately deal with leaks or possible water damage. At 65% of relative humidity (RH) germination of mold and fungus starts, and insects like *A.verbasci* also starts their activities in such environment.[29] Some important insects often found in museum are shown in given below Fig.1.

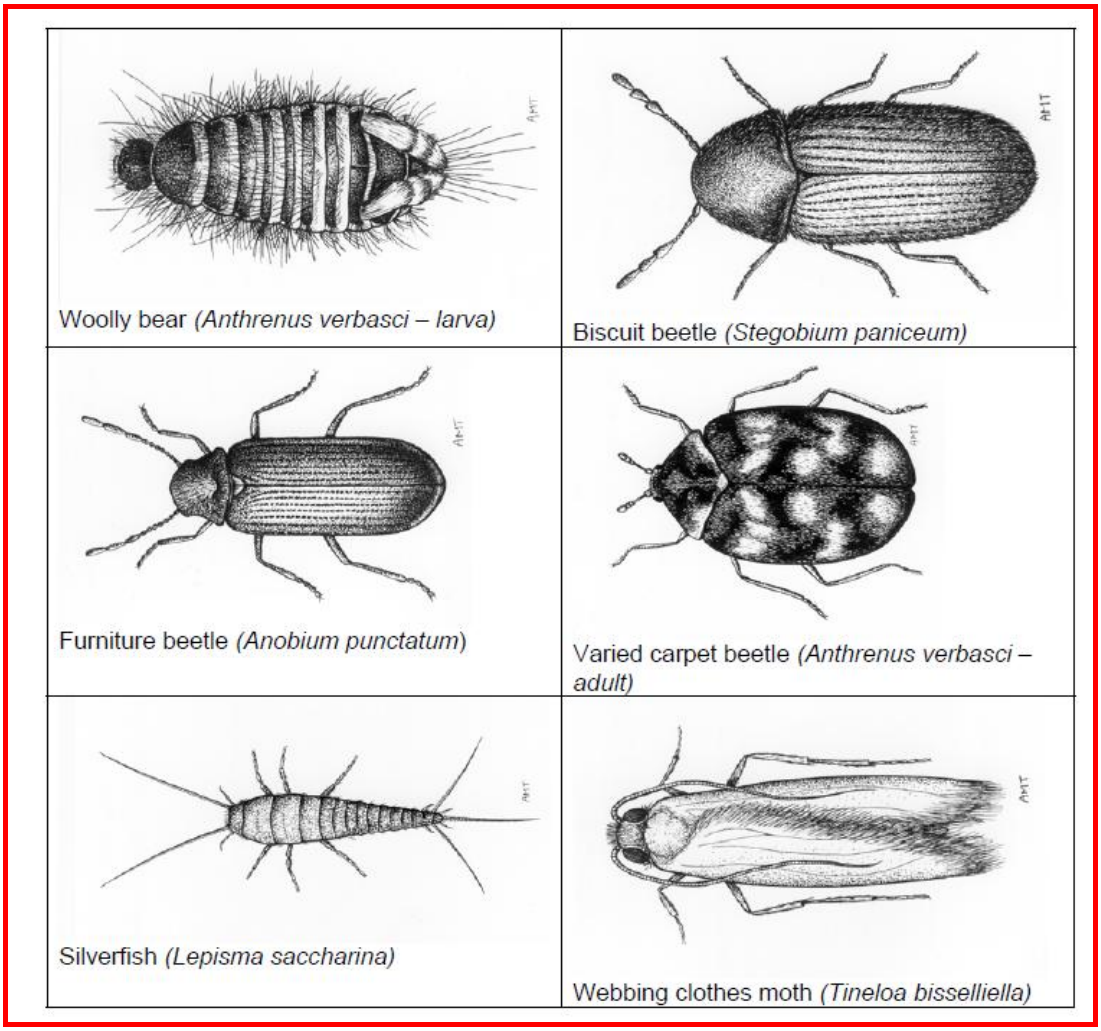

Fig.1. Demonstrating important insects found in museums, libraries and archives

4.5. General Pests

General pest are any household pests that enter into a building through windows, doors, cracks in any museum. These pests may cause damage to the museum and their objects. The most common damage occurs from the nesting and feeding behaviors. They generally strive on cellulose rich material such as sizing material, binding material etc. Birds, rodents, mammals etc, can be kept in this category as well.

(i) Rodents:

Apparently, if your museum has a rodent infestation as the pests, it will leave behind droppings and gnaw traces. Rodents will breed rapidly and begin shredding and nest in objects they come into contact with. It is important to note that rodents will not discriminate between valuable objects, packing or rubbish [30, 31]. It is important to never use rodent bait, because poisoned rodents often crawl away and die in unreachable areas, such as between walls and under furniture, and their carcasses provide food for other pests. Traps should be used to remove rodents from the museum in a more humane manner that will prevent the rodents from attracting more pests or causing larger problems [32].

(ii) Birds and bats

Birds may cause damage to the exterior of the museum when they roost or nest on windowsills, ledger, and other architectural features. Bird droppings may cause staining and damage to the building and as well the fabric that is attached to the building. Museum staff will also need to be careful when they are around birds and items infested by birds as they can pose a health hazard to humans as they carry parasites and disease. Bird droppings can also be tracked into the museum and collection space, and by working to remove the

birds from entrances, the tracking of the droppings can be controlled. Bats may also cause damage to the buildings as birds as respectively. [33].

(iii) Big mammals (rabbits/cats)

Big mammals/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.

5. Components of IPM

The methodology used in the preventive management program is very simple and is based on self-improvement. There is a pyramid of methodology used in preventive integrated management program represented by Fig.2. It can be carried out repeatedly by the museum and the steps involved are given below:

1. Discovery
2. Focus
3. Improvement

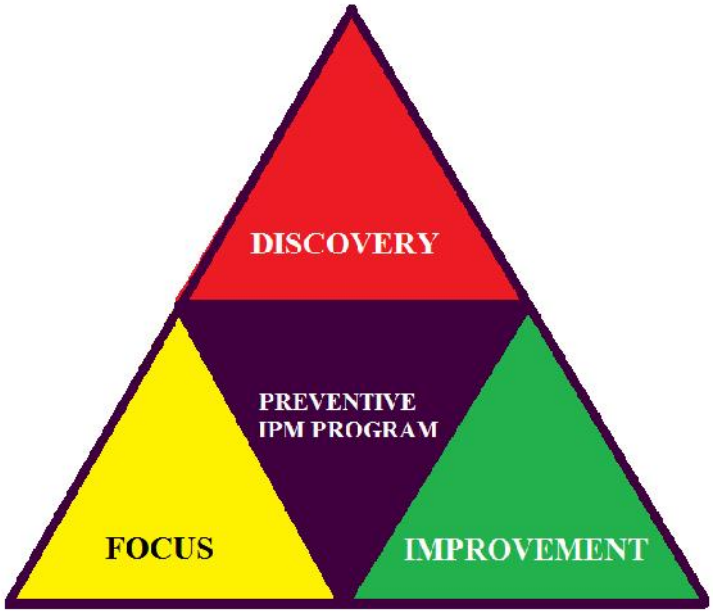

Fig.2. Representing pyramid of methodology used in preventive Integrated Management Program

The process starts with discovery step where it can discuss the area, their strength and weaknesses which need improvement with regards the building, collection, storage and environment. After discovering the strength and weakness, the next step is to focus on the priorities of preparing the plans for the improvement. It can be of short term, medium and long term plan. And the most important step in preventive conservation is improvement by implementation of different levels of expertise. To understand the nature and extend of biodeterioration that museum objects might undergo it would be necessary to have an idea of the observable symptoms that are caused by different type of deterioration on various kinds of materials. The symptoms vary depending upon the species of the organism responsible for causing deterioration and the physico-chemical properties of the material affected. The 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 may lead to surer chance of success [34].

6. Principles of IPM

IPM principles rely on the understanding of pest biology and the museum environment to keep pests away from the collections and facilities and to prevent them becoming established. Typically, there are many facets to an IPM programme which are all interrelated. The success of the programme depends on each part of the programme being properly planned, adhered to, and supported at all levels which is shown in below by given Fig.3. Following below is a list of the IPM principles that can be employed in any typical programme [35-37],

They are:

1. Restrain the pests (insects)
2. Control over the entrance for pest (insects)
3. Figure out pests (insect) and their activities
4. Assessment of infested collections
5. Monitoring pest activity (use of insect traps)
6. Treating the infested problem of pests (insects)
7. Implementing IPM rules and procedures

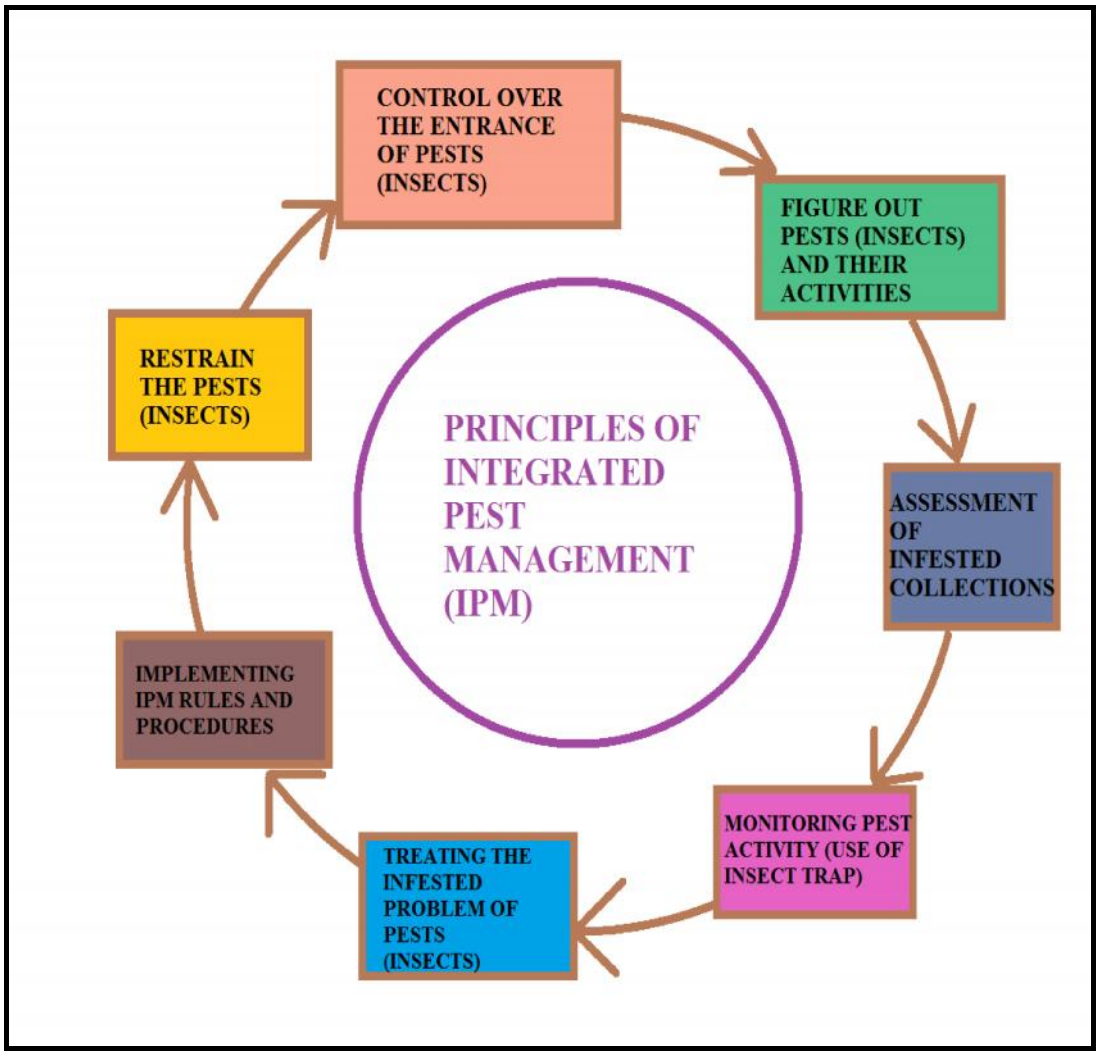

Fig.3 Represents the interrelation of principles of IPM

6.1. Restrain the insects

The most important part of the programme depends on the large part of the maintenance of the building and rooms. Dust attracts insects and provides them with a favorable habitat to their development. Repair all the areas through which the insect can enter the museum and the storage areas, cracks in the walls and the floors. The museum should install good quality of weather stripping. Identify the insects, and correct identification is vital to determine whether the collection is at risk. If it is in doubt consult the entomologist and seek help from the specialist. Keep a record that indicates the species found, its stage of

development, the date, the location at which it was found, and the name of the person who found the insect. Study the record after every inspection. If the species captured is a threat to the collection, inspect vulnerable objects in the vicinity of the insect sightings. Examined the concealed areas where the insects prefer to hide inside the pocket and folds, or in the upholstered furniture or natural history specimens. The proper treatment that fulfils the criteria is the key of a successful IPM program because these controls work without extra human effort, costs, or continual inputs of other resources. These treatments often include changing the design of the landscape, the structure, or the system to avoid pest problems. The following are examples of preventive treatments:

- Educating students and staff about how their actions affect pest management
- Caulking cracks and crevices to reduce insect harbourage and entry points
- Instituting sanitation measures to reduce the amount of food available to ants, cockroaches, flies, rats, mice, etc.
- Cleaning gutters and directing their flow away from the building to prevent moisture damage using an insect growth regulator to prevent fleas from developing in an area with chronic problems.

So, the success of the pest management programme depends heavily on the maintenance of the building, rooms, display cabinets, storage area and drainage. Dust and dampness attracts insects and provide them favorable conditions to germinate. All hard to reach area should be cleaned, and vacuum cleaning should precedence over all other equipments. Discarding of vacuum cleaner bags frequently is the most important part. All garbage bins should be emptied and cleaned before closing of premises. Storage area should be cleaned on monthly bases and natural history collections and other art materials should be kept in cup-boards or boxes. Display area should be cleaned after every 15 days. Outside building and facade should be check periodically against vegetation and other biological activities such as bee nest, bird nests along with debris, dead trees and rubbish. Unwanted packing material and used packing material should be stored separately from natural history collection's storage. There should be a continuous monitoring of leakages from water storage, plumbing and drainage as well. Foods and beverages should not enter into the main building and if possible pantry or cafeteria like facilities should be considered in a separate building

6.2. *Control over the entrance for insects*

It is a method that describes mechanism of eliminating insects which includes the vaccum cleaning as an essential part for:

• To improve the galleries.
• To diminish the spread of infections.
• To create disturbances in the life cycle of the insects (varied carpet beetle).

Apart from vacuum cleaning it is also important to understand the other possible entry points of museum pests in the building, which is shown below in following Fig.4. These possible places can be cracks on floor, wall or ceiling, air vents and ducts. If any of these are found, it has to be repaired immediately. Inspection of building from inside and outside has to be done periodically and has to be recorded. The conservation facility or inspection room should not be in gallery or storage area. It has to be on different floor or building where, new acquired animal collections or biologically infected materials are treated before merging with rest of collection.

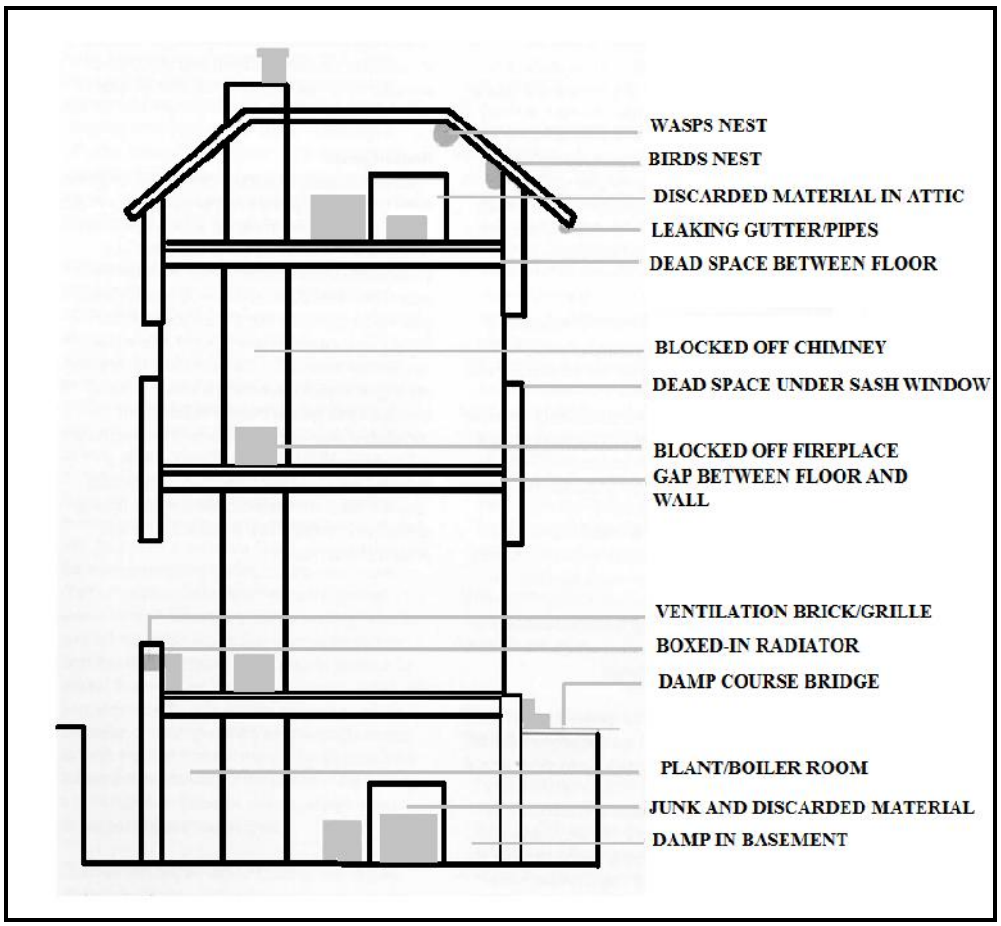

Fig.4. Represent a diagram to show key pest points in an older building

6.3. Figure out the insects and their activities

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. There are many sign through which infestation of insects can *be inspected such as insect's* frass. Frass is the finery powdery debris left by insects and is mostly excrement not fragments of the material which developed through boring or eating.

Programme of insect 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.

6.4. Assessment of infested collections

Strang and Kigawa in 2006 have described the relationship between levels of control and damage to materials and thus setting the first step towards risk management [38]. Infected manuscripts have to be isolated and assessed properly in sealed polypropylene bags from rest of collection and sent to conservation unit for further study. Proper documentation has to be completed in this stage related to identification of insect, its life cycle, if it has laid eggs and kind of damage it has caused to the collection. It has to be documented by both the picture and graphic description. If the infestation is still active or dormant has to be identified and if it is still active, it shall be sent for elimination of the insects [39].

As part of pest control strategy things need to identify are:

- The parts of collection that are most at risk
- The parts of the building that are most at risk
- The activities that might present an opportunity for pests over to conservation unit to eliminate the insects.

By reviewing the above, one can determine the pests most likely to be attracted to the collection. Next, investigate their life cycle, seasonal activity and habits. Only then any action can be decided according to its priorities. The following basic checklists of pest activities are:

- *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 kind of 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, or in hidden areas of older buildings.

6.5. Monitoring insect activity (use of insect 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. The following Fig.5 represents diagram to show the placement of traps in a museum store.

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 labeled and their position marked on a plan. 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 [40, 41].

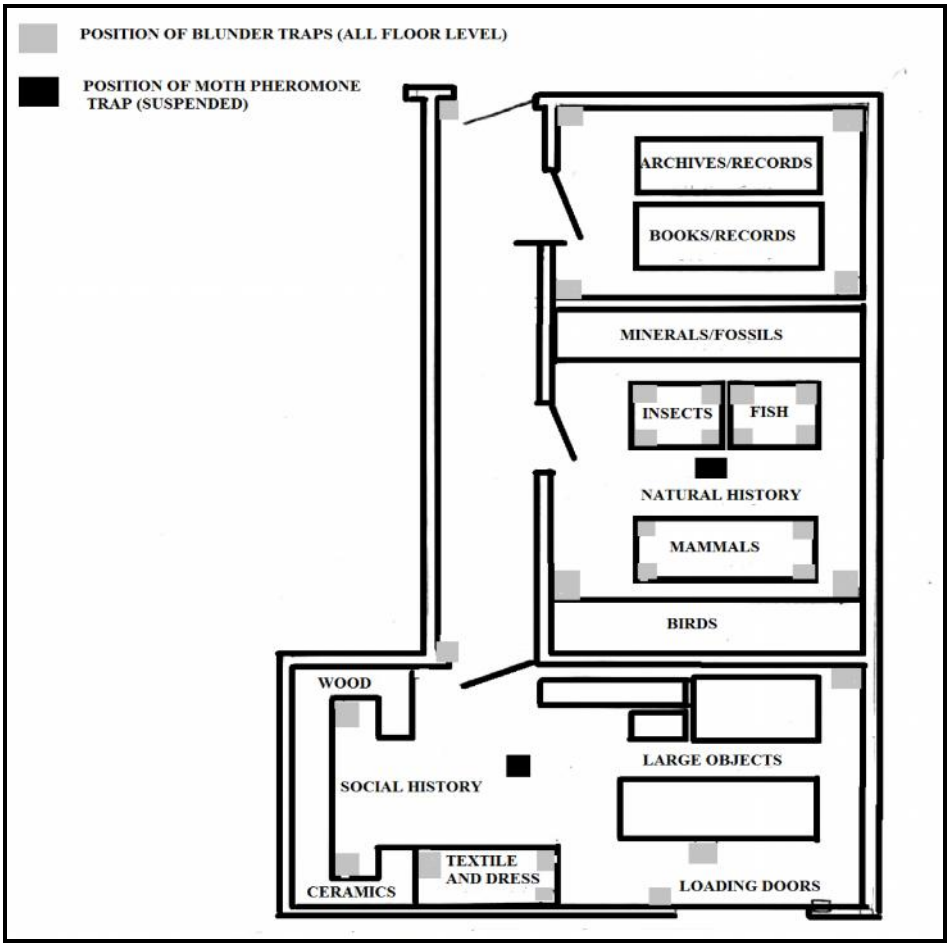

Fig.5.Represents a diagram to show placement of traps in a museum store

6.6. Treating the infested problem of insects

In the western world in the past variety of insect repellents were used for elimination of insects, such as cedar oil, naphthalene balls, paradicholoro-benzene crystals and camphor etc. However with more experience and study it is found that these repellents do not kill insect. Some museums and libraries are regularly using insecticides such as methyl bromide and ethylene oxide. These insecticides are generally effective in killing pests but it also possess great health hazard to the humans. In India too, there has been lots of insecticidal chemicals have been used for terminating insects in the fumigation chamber. The following Fig.6 represents the diagram for a quarantine strategy for a collection.

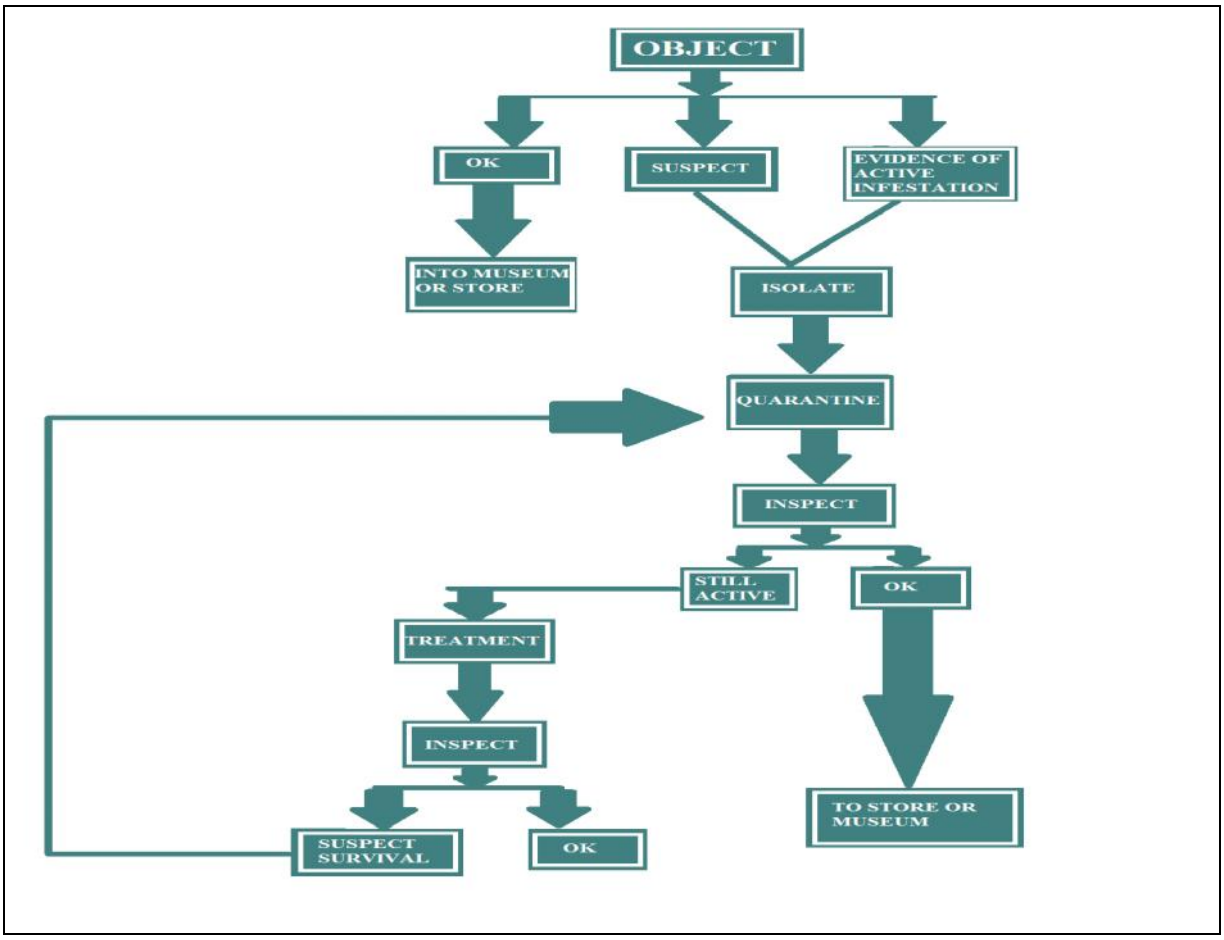

Fig.6. Demonstrates diagram for a quarantine strategy for a collection

Moreover, these insecticides are also not completely effective in killing the insects. Many of these chemicals are carcinogenic or suspected to be potential carcinogenic. To solve these problems, there has been constant research and technique evolved in the conservation science [42]. Some recommended methods are as follow:

i. Exposure to Freezing Environment
ii. Exposure to Anoxia Environment
iii. Exposure to Nitrogen (N_2) Environment
iv. Exposure to Carbon Dioxide (CO_2) Environment
v. Biological Control
vi. Radiological Control
vii. Least-Toxic Chemical Control

(i) Exposure to freezing environment

Freezing natural history collections to the low temperature does not cause health problem to the museum staff but it can resist growth of insects. However, there are many insects found who are susceptible and can survive in low temperature if dropping of temperature is gradual. But, if the collection would be exposed to the low temperature like *20 ºC (5 ºF)* immediately for the period of a week, no insects may survive in that climate.

However, when the collection like stuffed bird or freeze dried specimen is taken out of freezing environment, sometimes water condensation may take place in it, and if it becomes out of control it can lead to a massive problem [43-49].

(ii) Exposure to anoxia environment

Another safe and effective method to kill insect is to expose infected manuscript in the oxygen poor environment. All living elements requires oxygen to breath, hence infested collections are supposed to kept in a chamber which has environment low in temperature and rich carbon dioxide or nitrogen for a period of a week, insects in each stage of life cycle will be disrupted [50].

(iii) Exposure to *nitrogen (N_2)* environment

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 [51, 52].

(iv) Exposure to carbon dioxide (CO_2) environment

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 [53.].

(v) Biological control

The technique of the biological control has the advantage of being less hazardous, non-polluting and offering less chance of resistance development. Entomologists are also engaged in research field of conservation of the cultural property to find out the enemies in terms of common insect, which are harmful for museum collections. Spectacular success could be achieved by merely taking the help of nature. According to a report, this technique is being used in China, India, Japan and other countries to control the menace in agricultural field. These natural enemies of some insects could be predators, parasites of pathogens. Some micro-organisms like fungi, bacteria and virus also cause fatal disease of pests. However, this technique still requires lot of research and specialization with adequate availability of predator insects and fungus. Removal of predator insects and contain their germination is also a problem to address [54]

(vi) Radiological control

The Radiological control technique that is the sterile insect technique (SIT) has added a new dimension to pest population containment, management and eradication, containment, management especially in the field of the agriculture [55]. It has a feature that could contribute to a better solution for a wide range of important pest problems in an effective, economical and ecologically sound manner. It is widely used to eradicate and to control insect pests. However this technique requires lot of funding and state of art equipments as it emits gamma rays to control insects. For museums and libraries in India, it is very impractical method at this stage.

(vii) Least-Toxic Chemical Control

If the museum or libraries or archive still wants to use insecticide chemicals it has to be followed with many precautions. The health of users and long-term suppression of pests must be the primary objectives that guide pest control. To accomplish these objectives an IPM program must always look for alternatives first and use pesticides only as a last options. There are many other chemical products to choose from that are relatively benign to the larger environment and at the same time effective against target pests.

6.7. Implementing IPM Rules and Procedures

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 according to changing needs and priorities. Implementing an IPM programme for large collections 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. A suggested plan of actions is as follows.

i. Survey the situation
ii. Develop or assess IPM procedures
iii. Training the staff
iv. Documentation and evaluation
v. Health and safety measures
vi. IPM and the future

(i) 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.

(ii) Develop or Assess IPM Procedures

It is important to:

- 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 and furniture etc.

(iii) Training the Staff

Some IPM tasks such as monitoring can be shared by several members of staff, depending upon the size of the collection and staff structure. Hence, it is important to monitor that the work is being done as specified and their staff are adequately trained.

(iv) Documentation and Evaluation

It is obligatory to document every action taken to restrict the activities of pests in the museum, archive or library. In tropical country like India, seasonal variations are on extreme end and this leads to the various problems related to the insects. Maintaining proper and through documentation of entire process of locating insects, its life stage, where it was found, how is was eliminated and in next season did the same problem occurred, kind of questions can help in evolving IPM policy to a stage. Hence, without aid of insecticide, we can still control the insect activities.

(v) Health and safety measures

The IPM manager 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 thoroughly read and followed.
- All pesticides and other chemicals must be stored safely and securely.

(vi) IPM and the Future

Due to the negative effects of some chemicals on staff, objects and the environment, there is an increasing pressure to move away from persistent and toxic pesticides to some natural and indigenous method of pest control. Therefore it is an utmost need for

integrating traditional and natural methods of pest control in the IPM of museums for the safety of human being, their environment and for the museum valuable collections as well.

Conclusion

To manage pest risks one needs to be able to assess their probability and impact and determine the magnitude of risk. Then risks can be evaluated, various scenarios can be compared and ranked. Pest risks can be considered in the larger context of collection care and compared with the risks of other agents. This allows setting priorities at the overall collection care level. This paper also highlighted the importance of integrating natural chemical control methods in museum's IPM guidelines, on the basis of its efficacy and availability in future. There are a considerable number of scientists and professionals studying pests risk and their control with natural or less toxic chemicals in their research laboratories. And indeed, there are many studies underway that may produce useful data in the near future to fill the gaps regarding this process.

Acknowledgments

The author is gratefully acknowledged to Prof. Abdurahim K, Department of Museology AMU Aligarh for providing necessary research facilities. We are also thankful to UGC for providing financial assistance to complete my research work.

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Quick Response Code

DOI:10.22192/ijarbs.2019.06.09.016

How to cite this article:
Fatma Faheem, Abduraheem K. (2019). Management of pests risks in museums: A review. Int. J. Adv. Res. Biol. Sci. 6(9): 122-136.
DOI: http://dx.doi.org/10.22192/ijarbs.2019.06.09.016