A BIOLOGICAL DISASTER TO COSTUME

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ABSTRACT - Natural disasters come in many forms, but rarely is an entire museum's collection inundated with a predatory insect infestation. In the fall of 2006, the Smithsonian's newest museum, the National Museum of African American History and Culture (NMAAHC), requested that the Museum Conservation Institute (MCI) assess and evaluate the condition of the Black Fashion Museum (BFM) in Washington, DC. Its former director and owner, Lois K. Alexander, had traveled the United States collecting garments designed, sewn, and/or worn by African Americans spanning the 19th and 20th centuries; she headed the Harlem Institute of Fashion before founding the BFM and moving the collection to Washington, DC. However Lane was now incapacitated; while the family continued to manage the collection they found it overwhelming. Her daughter sought to donate the collection in its entirety to the new Smithsonian NMAAHC. The BFM filled a two-story townhouse with costume and accessories. When the Smithsonian inspected and evaluated the collection it was stored in a closed environment and infested with live carpet beetles in all stages, along with spiders. This paper will recount the survey, removal, initial treatment, and rehousing for this stunning collection that took place from 2007-2014.

1. INTRODUCTION

The Black Fashion Museum, (BFM) was founded by Lois K. Alexander in 1979 in New York City as an outgrowth of her Haarlem Institute of Fashion (Taylor 1982). Mrs. Alexander Lane's life work was to shine light on the historic and contemporary contributions made by African Americans to American design and fashion. Overwhelmed with the legacy and its responsibility, her family sought to donate the entire Black Fashion Museum's collection and associated archival materials to the National Museum of African American History and Culture (NMAAHC) which opened September 24, 2016 (fig. 1).

The extensive BFM collection has objects ranging from the mid-19th century, to the mid 1980s. It contains pieces created and worn by slaves, former slaves who became tailors and designers, a number of 20th century black designers of couture clothing and furs, as well as garments worn by black entertainers and other African Americans from all walks of life (Smaltz 1982). The collection includes a dress that Rosa Parks was working on for herself before her famous arrest in Montgomery Alabama, as well as theater costumes from *The Wiz* by Geoffrey Holder, and debutante gowns designed by Anne Lowe, the African American society designer who created Jacqueline Bouvier Kennedy's wedding dress (Mitchell, as referenced in Alexander1982, 22).

In the fall of 2006, NMAAHC requested that the Museum Conservation Institute (MCI) assess and evaluate the condition of the BFM holdings. By this time, Mrs. Alexander had long before transferred the museum and its contents to Washington DC (Vermont Avenue NE); she had become chronically ill and incapacitated (Bailey, 2007). When the evaluating team from MCI and NMAAHC arrived at the townhouse they found the upstairs rooms filled with costume, much of it in open storage; the kitchen area and an upstairs pantry were filled with archives, photographs and files. There were mannequins in the stairwell, and boxes of returned loans in the living room. Apart from a few fold-out chairs in the 'dining room' and an upstairs study with a desk and typewriter, the entire house was devoted to black fashion. Unfortunately, MCI discovered an active infestation; throughout the collection were the larvae of what are now characterized as varied carpet beetles, though initially they were thought to be furniture carpet beetles.

Carpet beetles are ubiquitous throughout North America. The varied carpet beetle (*Anthrenus verbasci* L.) and the common carpet beetle (*Anthrenus scrophulariae* L.*)* are very similar both are 2 or 3mm long as adults. The varied carpet beetle has a brownish and yellow irregular (i.e. "varied" pattern) on a black background on its back; the common carpet beetle also has a black background with whitish small spots and a red-orange strip down its back. The furniture carpet beetle (*Anthrenus flavipes,* LeConte) is the same size. Its back is black with yellow and white scales, though its ventral surface though is white. Story groups the varied carpet beetle and the furniture carpet beetle together in terms of bionomics (Story, 1985; Black, 2004). (fig. 2)

2. BIONOMICS OF CARPET BEETLES

There are four stages in a carpet beetle's life: the egg, the larva (fig. 3), the pupated form, and the adult (Story, 1985). Carpet beetles are essential to the ecological balance: without them we would be knee deep in dander, feathers, and decay, but they are a biological enemy of clothing preservation. Adults are small and rounded, measuring 3-5mm, a fraction of the size of a ladybug. They are attracted to spring flowering plants, and eat pollen and nectar. Since they are also attracted to light, adult carpet beetles can often found near windows which means their presence can be monitored indoors with unbaited sticky traps laid flat on window sills. Females can lay 30-40 tiny eggs on a food source, such as a dead animal or an object in museum collection storage. Larvae prefer dark secluded places and take anywhere from 3 to 36 months to develop.They begin to feed as soon as they hatch and are described as 'voracious.' They have 5 to 16 instars (molting up or down) depending on environmental conditions. Larvae will bite will bite anything once, wool or synthetic fiber. The pupal stage takes 12-15 days, and then the cycle begins again (Black, 2004; Story, 1985).

Carpet beetles are not casual itinerants; the adult female has wings and will fly towards light to find a mate. Certain shrubs and flowers act as hosts for the male and female mating. The female then seeks to lay eggs on a probable substrate. Otherwise, the various stages of the larvae do not stray far from their food source. Oftentimes, an infestation can remain somewhat isolated. However, in this instance the infestation had spread throughout the building, indicating a long incubation.

3. BLACK FASHION MUSEUM INFESTATION

The most dramatic discovery was an upstairs closet tightly packed with garments adjacent to a sealed walled-up chimney; there, a pile of red powder was found on the floor beneath a red wool coat. This former chimney may have remained partially or fully open at the roof line so that feathers and nest debris had dropped down. When the food source was depleted in the chimney, some larvae or adults might have found a miniscule crack to reach the red wool coat eating their way up the hem and around the collection. Larvae cannot digest dye—a small percentage of the weight of the processed wool fabric--hence the small red frass mound below (fig. 4).

Alternatively, Black Fashion Museum clothing sent on loan might have been returned infested with eggs of carpet beetles. If the loaned clothing were re-shelved or rehung without vacuuming and/or brushing all seams and surfaces inside and out, an infestation might have been introduced that way. In addition, the Black Fashion Museum was developed at a time when clothing accessioned into a museum collections was modeled for patrons at annual luncheons—perhaps by one or more of the patrons themselves. Lois Alexander was a principal at the Haarlem Institute of Fashion: some students might well have worn the clothing. Inadvertent staining or soiling from these or other activities can provide essential nutrients for keratin digesting insects.

4. PROTOCOLS

Like other kinds of disasters only one or two knowledgeable staff members are needed during the initial survey to assess the extent of damage, identify the insect(s), and be familiar with the type of collection affected. The initial responders needed to have a general knowledge of costume and fashion history. This initial staff devises a plan of action and goals for treatment. They get approval and authority to purchase supplies, and assemble and coordinate a larger working group.

Unlike other kinds of disasters a pest infestation can travel home with the responders, replicating the infestation among their own clothes, furnishings, and heirlooms. This disaster can infect their laboratories or studio spaces, or their museum's collection storage. An infestation can passed to their friends and relatives, so precautions must be taken.

It pays to be vigilant. Restrict access to the infestation site. Do not travel from the site, to work, or home. Assume *everything* is afflicted, infested, and embedded with larvae and eggs. Wear aprons, or disposable Tyvek coveralls. Immediately bag work clothes at the end of the day; seal and label the bag. Wipe the bag with disposal towels before bringing it into the home. Workers should immediately wash their hair and body. The contents soiled work clothes should be opened directly into the washing machine; after washing & drying, ironing is recommended. A box of unused bags and sealing tape and a change of clean clothes bagged and sealed in car should be kept in the car.

For the team working at the BFM, there were some advantages; it was summer in Washington, DC. This allowed them to wear washable, non-edible, cotton work clothes and washable sneakers, not woolen coats or sweaters. The location allowed for the direct order and delivery of all supplies, and there were trucks available for transporting the collection supplies.

There were also some disadvantages; it was summer in Washington DC. Doors and window had to be kept closed, and without air conditioning, the urban space became hot and stuffy as the spring quickly changed into summer.

5. TRIAGE AND PACKING

The first step of the rescue was the sorting and packing of the collection. All that was needed were a few tables, tissue paper, boxes, packing tape, marking pens for the boxes, a digital camera, and pens and paper to enumerate the contents of each box so the location and objects could be connected (e.g. LR-6 meant Living Room Box 6).

After everything was boxed the still infested collection was placed in a truck and taken to MCI located at the Smithsonian Institution's Museum Support Center (MSC) in Suitland, Maryland for anoxic treatment with argon gas and zeolites. All boxes were removed at one time in order to conform to security protocols; someone stayed with the truck at all times; the boxes were checked and accounted for.

6. ARGON

Argon is a clear, colorless and odorless gas at room temperature and pressure (table 1). It is characterized as a noble gas; its outer p subshell is entirely filled with electrons, and it is inert, monoatomic, and stable (Merck, 2006).

Table 1. Physical Properties of Argon (Hwang and Wettmer, 1995; Merck, 2006)

Property	Argon
Atomic number	18
Atomic Weight	39.948
Critical Point Temperature, K	150.86
Critical Point Pressure KPa and psi	4898 and 710.21
Critical Point Density kg/m3	535.7
Normal boiling ppoint, K	87.28

Solubility of gas in Water, 20ºC, mL/kg	15.759 or 33.6 cc/kg water

Argon is found naturally among the nine fundamental components of air when freely sampled (Table 2), with four others also being noble gases in trace amounts.

Table 2: The Principal Constituents of Air (Hwang and Wettmer, 1995)

Gas	Concentration µL/L	Minimum work of separation at 300K, kJ/Mol	Normal boiling point, K
Nitrogen	780,840 ± 40	1.68	77.35
Oxygen	209,460 ±	6.11	90.19
Argon	9,340 ± 10	14.11	87.28
Carbon Dioxide	300 ± 30	22.73	194.67[a]
Neon	18.21±	29.72	27.09

[a] Sublimation temperature

Argon is commercially available as a compressed gas and is sold with various grades of purity, rated from B through F, with E being the purest (meaning the lowest level of (µL/L) of all contaminants), and with F the lowest with water as a contaminant (table 3).

Table 3: Commercial Specifications for Argon (Cady & Cady, 1945; Hwang and Wettmer, 1995)

Specification	Compressed Gas Association Grades				
	B	**C**	**D**	**E**	**F**
Minimum purity	99.996	99.997	99.998	99.999	99.9985
Total Maximum impurity, µL/L	40	30	20	10	15
Water	14.3	10.5	3.5	1.5	1
THC*a* as CH4	5*	3*	0.5	0.5	0.5
oxygen	7	5	2	1	2

nitrogen	15	20	10	5	10
hydrogen	1	1	1	1	1
CO2	*	*	0.5	0.5	0.5

[a] Total hydrocarbons, reported as methane.

*THC measurement includes CO2.

Argon is used industrially to shield metals from reaction with atmospheric oxygen and nitrogen during heating and melting. With stainless steel, it is employed in the decarburizing process; with other specialty alloys it is used in refining, casting, and annealing. Argon/nitrogen gas mixtures are commonly used to protect and prolong the life of the tungsten filament of incandescent lights (Merck, 2006). Other applications include the use of Argon as the insulating layer between panes of glass for double paned windows in commercial and residential buildings (Fisette, 1998), for permanent wedding dress storage (Rising, 2001), for the anoxic suffocation of insects Koestler,1992), as well as mold control and deodorization (Shiner, 2007). This last treatment, deodorization, is carried out in conjunction with zeolites, molecular sieves that have an extraordinary capacity for absorption (Kühl and Kresge, 1995).

7. ZEOLITES

Zeolites are microporous crystalline silicates or aluminosilicates that have useful applications as molecular sieves. Zeolites trap molecules selectively, based on size and polar properties (Dyer, as referenced in Rempel, 1996) Adsorbed molecules are held in place within the internal cavities of the zeolites by physical and chemical bonding (Hollinger, 1994). Thus, sufficiently adsorbent zeolites can function to trap undesirable gaseous chemicals present in an environment, including sulfur dioxide, nitrogen dioxide, acetic acid, carbon disulfide, formaldehyde, and ammonia. Furthermore, zeolites are inert and non-reactive, and therefore suitable for use near objects (Rempel, 1996). For argon treatment, a 25 lb. bag of the natural zeolite clinoptilolite was transferred to heavy cotton canvas fabric bags that are open, and porous to air but not dust; the bags were placed in each bubble to act as molecular traps for deodorization. The Z-Filter Media zeolites, CAS 12173-10-3, that were used for the BFM collections are not combustible and do not produce hazardous waste; they are routinely used in filtering swimming pools.

8, ARGON "DEODORIZATION" TREATMENT

The boxed garments were placed in two chambers (bubbles) each measuring 8 x 11 x 11 feet (968 sq. ft.). When treating such an infestation with argon gas, a closed environment with less than 1000 parts per million (ppm) of oxygen present must be maintained for 30 consecutive days to suffocate all stages of carpet beetle activity. Argon is an inert noble gas, and therefore is nonreactive and safe for use with all materials.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) has not received the regulatory documentation for argon to be used as a commercial fumigant for pest control. Technically, a fumigant must be approved for each insect species for which it is licensed. The approval is based on extensive laboratory research and formal experimental work documenting specific dosages insect stage by insect stage. Because argon is a freely available gas there is no commercial incentive to undergo such expensive testing. Nonetheless, a non-oxygen atmosphere may kill both insects and humans. Hence, the same level of documentation carried out by standard fumigation procedures and the same safety features are required for prudent, successful treatment. What transpires can be referred to as an "argon treatment," not fumigation. By adding bags of zeolites, this treatment can be formally titled a "deodorization" and eliminate statutory confusion for management and the state agency assigned to enforce pesticide regulations.

Corrugated boxes contain air that must be pumped down several times using a vacuum to reduce number of Argon replacements (fillings) needed to reach the required oxygen level. It is helpful that argon is heavier than oxygen. The object filled boxes are on the ground with the argon, the oxygen rises above the objects as argon in pumped into the chamber.

Without time to test for a lack of oxygen, similar to the atmosphere that causes Prussian Blue to go colorless and vat dyes to go into a leuco, soluble—dye bleeding—state, susceptible textiles (indigo, bright blue cotton upholstery) were isolated before being moved from the BFM museum with tissue and/or Ethafoam. After treatment, nothing was seen to have bled or altered in color.[1]

The cost of argon treatment is roughly comparable to that of surlfuryl fluoride, a common commercial fumigant. Additional savings in this instance were in the form of government workers, interns, and the security guards at the MSC facility who were already in place. Temperature and humidity were easily maintained as the building is purpose built to hold collections, and again at no additional cost to the project.

8.1 ARGON TREATMENT SAFETY MEASURES

Once the bubble is prepared, treatment with argon may begin only if all proper safety precautions are taken. Anoxic conditions are deadly to aerobic organisms, including humans. The authors of this paper are all state-licensed pest control operators (PCOs) in the fumigation category currently, or were in the past and cognizant of safety training. The Indoor Air Quality monitoring system used in the room manufactured by Yes Environmental Controls could only record levels of carbon dioxide, temperature, and

[1] A formal experimental paper on Prussian Blue fading in the absence of light has now been submitted to JAIC.

humidity. MCI purchased the four two year disposable gas Detectors (*Gas Alert Clip XT Detectors*). They were activated and tested to determine the alarm types (loud noise, intermittent strobe flash, and vibration) as well as to confirm oxygen sensitivity. Low oxygen level alarms were set to begin below 19.5% by volume. If Argon is used on a routine basis, the purchase of a "Yes monitoring System for Oxygen" would be worthwhile. At least two of the four disposable detectors were kept in the room at all times.

Precautions to ensure safe argon bubble use include:

- Treatment requires a minimum of a two-person team during filling and monitoring.
- All staff and technicians working near the bubbles must wear oxygen monitoring devices (dosimeters).
- Oxygen monitors with alarms must be present outside the bubble or chamber.
- Conditions inside the bubble are remotely monitored using dataloggers and oxygen sensors.
- Placards notifying staff of treatment in progress must be posted.
- Doors to the treatment room must be kept closed, locked, and monitored.
- The treatment room must have a land-line telephone if cell phone reception is limited.
- Emergency plans, including evacuation procedures, must be in place.

Those safety measures were followed during the anoxic treatment, and apply to all large scale anoxic treatments: always have a partner present, always have a cell phone, use oxygen monitors that will sound an alarm if the oxygen level outside the bubbles become low (below 19.2%). The room containing the chambers was locked with limited, carded access in a high security building. MSC guards were present 24/7 outside the area and kept a log book monitoring the presence of staff in the restricted area.

8.2 COMPARISON TO OTHER FUMIGANTS

This treatment was carried out June through September of 2007 in order to achieve more than 30 consecutive days of oxygen levels below 1000ppm (0.1% by weight). The oxygen level was checked and maintained daily. The plastic bubble containers used were meant for use with carbon dioxide, which operates with a more relaxed maximum of 6% by weight oxygen (60,000ppm). Leakage with carbon dioxide is not as critical as it is for argon. For oxygen levels to be kept below 1000ppm, the concentration of argon had to be "topped up;" this took 2-5 hours/day.

There are other anoxic treatments that will stress an insect's respiration. Carbon dioxide was used for many decades with other restricted use fumigants as an adjuvant and a means to reduce flammability (Rice, 1969). It is licensed as a stored product pest fumigant in the United States and technically is a registered restricted use product when it is used to eradicate an infestation (EPA 1991, EPA 2016). It is used to control some museum pests in chambers and bubbles; because it is a licensed fumigant, normally these operators are licensed. Its limitations may be associated with the chemical reactivity of carbon dioxide, the active ingredient of Seltzer water, a mild acid. Its advantage may be found in the higher level of oxygen permitted during the operation of the chamber, so that a tight seal and constant monitoring are less important.

Nitrogen has been used both as an initial fill for a vacuum-purged chamber and as an anoxic treatment itself. Again, the cost of nitrogen compressed tanks are less expensive than those of argon, and comparable to those of carbon dioxide. Nitrogen may require a higher temperature (30º - 40º C rather than room temperature) to insure complete mortality, but like carbon dioxide, a little oxygen (0.4%) is does not affect the level of insect mortality (Gilbert, 1991). Nitrogen gas should be humidified above its 15% RH for organic material (Valentin and Preusser, 1993, Buss and Crews 2000). Nieves Valentin, directly compared the efficacy of nitrogen, argon, and Carbon dioxide with test insects that included carpet beetles and clothes moths found the argon atmosphere produced the best results. (Valentin, 1993).

9. REHOUSING

After 30 consecutive days of anoxia, the collection was no longer infested. The next step was removing any traces of the insects. The objects required thorough surface cleaning of every nook and cranny to remove frass, carcasses, and cast off casings. A dedicated laboratory was prepared and stocked with variable suction vacuums with HEPA filters, micro attachments and screens, tweezers, and archival storage supplies to receive and prepare the 273 boxes of BFM textiles for survey and rehousing.

There is no residual protection against pests with an argon treatment or with fumigation treatments. In fact, the dead carcasses are an attractive food source to start a new infestation. While surface cleaning it must be kept in mind that adult carpet beetles do not differentiate between fiber types, and new eggs could be deposited anywhere, especially where there are cast off larval skins edible to any new, live larvae. Moreover, degraded parts of the dead insects undetected or unnoticed by a future conservator could spot stain or discolor areas during wet-cleaning. Thus, *everything* has to be vacuumed inside and out, every layer and ruffle, every interior seam allowance and hem must be turned back and cleaned. Nozzles and micro-attachments must be washed after each use to control cross contamination. In addition, the laboratory space itself must be cleaned and kept free of debris, and adjoining lab spaces monitored. It is helpful to have someone on hand to develop expertise in diagnosing, repairing, and fixing vacuum cleaners.

After many hours of surface cleaning, and condition documentation, the garments were finally ready for any necessary stabilization and loss compensation, and ultimately for mounting and display in the inaugural exhibits of the National Museum of African American History and Culture.

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LIST OF FIGURES

Fig. 1 Lois Alexander Lane with pieces from her collection.

Fig. 2 a-c from left: a: Furniture carpet beetle (*Anthrenus falvipes*, Le Conte); b: Varied carpet beetle (*Anthrenus verbasci*, Linneaus); c: Common or Buffalo carpet beetle (*Anthrenus scrophulaia*, Linneaus). Figure 2c has its wings beginning to open; the others have their wings tucked under.

Fig.3 a-c Carpet beetle larvae from left: a: Furniture carpet beetle (*Anthrenus falvipes*, Le Conte); b: Varied carpet beetle (*Anthrenus verbasci,* Linneaus); c: Common or Buffalo carpet beetle (*Anthrenus scrophulaia*, Linneaus). The size of the larvae will vary with the instar or stage, about 2.5-6.5 mm (up to about ¼ inch long).

Fig.4 Left is the red coat with insect damaged hem, right resulting frass found below coat.