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Department of Biology & Chemistry,
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A Potential New Way to Reduce Bed Bug Infestations: Arthroshield 880

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Figs. 1-2. Anne counting and classifying bed bugs.

ABSTRACT

Bed bugs have long been a scourge of Western Society, and their incidence has dramatically increased within the past few decades. They can not only invade homes and apartments, but are becoming increasingly found in motels, dorms, and other places of lodging. Currently, the only way to treat a bed bug infestation is through the extensive use of chemical pesticides. Arthroshield is developing a new method to treat textiles (e.g. mattress bindings, mattress skid fabric, carpet bindings, mattress tape, etc) that, hopefully, will decrease the survivorship of bed bugs. We have been conducting preliminary trials since mid-December. Based on our preliminary trials, Arthroshield has been modifying their application procedure and we have been modifying the experimental set up in which to test new textiles. Some of our preliminary results appear to be positive. Funding for this study was provided by Dan Short and Kyle Bullock of Arthroshield.

INTRODUCTION

The common bed bug, *Cimex lectularius*, is a parasite that feeds off of mammalian blood throughout the night, but can be seen in the day if they stay attached to articles of clothing or other cloth-like material. Adult bed bugs are 5 mm in length, flat, of reddish brown color, and are without wings. Young bed bugs can range from 1-4 mm in length and have a clear yellow color. Bed bugs originated in caves within parts of the Middle Eastern and Mediterranean areas (Koganemaru and Miller 2013). It is believed that bed bugs began to feed on bats before transitioning to people that took shelter in the caves.

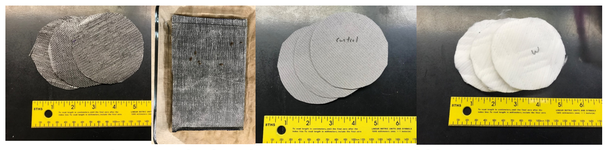
Bed bug populations slowly declined as pesticides became a way to control them in households. For the last few decades, infestations of bed bugs have increased dramatically as they became more resistant to the chemical (organophosphates) controls. Insecticides that bed bugs have the most resistance to are DDT and pyrethroids. There is a high resistance to DDT in many countries, but there is an extremely high resistance in cities of Sri Lanka (Karunaratne et al. 2006). Because there is an overly increasing resistance to pesticides, researchers are brainstorming ideas to prevent resistance from happening at a faster pace. Techniques that are being used to prevent this are natural treatments, and biological control, such as using fungi to help with infestations. Because there is a resistance to common pesticides, probable causes of new infestations are people returning from international trips or other countries are changing their pest management controls (Criado and Visconiellos 2010).

`In one article, Miller (2015) reviewed several natural treatments that have been used, such as vacuuming, steam heating, diatomaceous earth, and mattress encasements. Other treatments that can be used but not as common are pressurized carbon dioxide snow and heating systems. A natural treatment used is vacuuming, where a high-powered vacuum is used to eliminate bed bugs along with their remnants. A vacuum is not always effective on killing bed bugs since it is not guaranteed that the vacuum will remove the eggs from where they are attached. Steam heating has been an effective way to kill bed bugs but is a very time-consuming process (Miller 2015). Diatomaceous earth has also been used as a treatment because it sticks to the outer layer of a bed bug and absorbs their wax covering that prevents the loss of body moisture (Miller 2015). Mattress coverings are also a safe way to prevent bed bug infestation. A mattress casing prevents the bed bug from biting through and infesting mattresses or box springs (Miller 2015). Bed bugs have also been treated with extreme cold temperatures. Some companies use highly pressured CO_2 snow at a temperature of -108°F. This treatment will not treat an infestation of bed bugs by itself and is also a very time-consuming process to use (Miller 2015). Lastly, heating systems can be used to expel bed bugs at a temperature of 114˚F to 115˚F. As an infested room is pumped full of heated air for an hour, it will reach into areas that other treatments are unable to do. Once the temperature has reached to 114 to 115˚F, bed bugs will start to die off until the treatment is done. This treatment is very time consuming and expensive, and since it is so new it is hard to find a company that has this technology (Miller 2015).

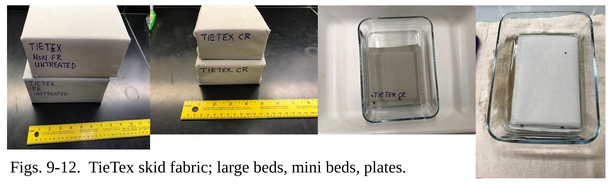
Considering the effectiveness of the natural treatments discussed above, there are new ways of decreasing infestation. For instance, researchers are testing the effectiveness of a fungus, *Beauveria bassiana* (Barbarin et al. 2012). This method has deemed itself to be more successful than other treatments. Other techniques being tested are treating materials in which bed bugs are likely to encounter, such as skid fabric, mattress ticking, mattress tape and other cloth like materials. Arthoshield is a company that has created a patented treatment of textiles, hopefully to reduce the possibilities of bed bug infestations. We are testing their treated materials for bed bug survivorship.

MATERIALS and METHODS

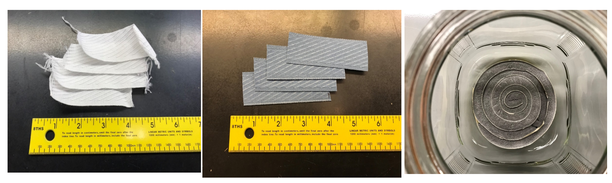
To date we have conducted 16 trials (Table 1) testing materials from Shaw Industries, TieTex, Culp, Preferred Finishing, and Duck. For Shaw Industries, we conducted three trials (trials 1, 6, 14) on discs and plates that have two treatments (Figs. 5-6). TieTex skid fabric (trials 2, 5, 8, 11, 12, and 13) was tested on large beds, mini beds, discs, and plates with five different treatments (Figs. 7, 9-12). Culp mattress ticking was tested on discs for one trial (trial 10). For Preferred Finishing, three trials (trials 4, 9, 15) were conducted on treated mattress binding (Fig. 13-14). For trail 16, Duck is currently being tested treated weathering strip (Fig. 15).



Figs. 5-8. 5-6. Shaw carpet binding, discs, plate. 7. TieTex skid fabric. 8. Culp mattress ticking.

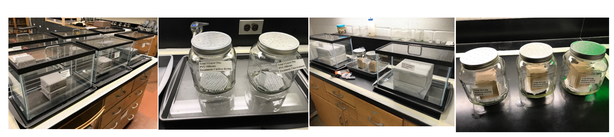


Figs. 9-12. TieTex skid fabric; large beds, mini beds, plates.



Figs. 13-15. 13-14. Preferred Finishing mattress tape. 15. Duck weathering strip.

Treated and control materials were tested in three types of containers: cookie jars, 5.5 gallon aquariums, and 3 cup Pyrex dishware. Cookie jars used measured 14 cm x 14 cm x 17 cm x 10 cm opening purchased at Dollar General (Figs. 17, 19). 5.5 gallon aquariums measured 21 cm x 26 cm x 40 (Figs. 16, 19). Lastly, 750 mL Pyrex casserole dishware measured 19 cm x 14 cm x 4 cm and purchased at Walmart (Figs. 11-12).



Figs. 16-19. Aquariums and cookie jars that were used during the trials.

Wooden blocks (red oak, 5 cm x 5cm x 7.5 cm) and binder clips (ACCO Item #44710) were also used to compress the materials placed into the containers to encourage the bed bugs to get between the materials (Fig. 20).

Measures to prevent bed bugs escaping include a "moat" and a "sticky field". Each type of container was placed into a cookie sheet (28 cm x 42 cm x 2 cm) or a baking pan that was then filled one third with soapy water. If the rare case of a bed bug escaping would have occurred, the bed bug would die in the soap water (Figs, 16-18).

Before bed bugs were counted each day, temperature and relative humidity were measured using a data logger (Elitech GSP Temperature and Humidity Data Logger Item #X001ID6ZIZ) (Fig. 21).

Initial trials began in Lappin rooms 333, 325 in a growth chamber, and 130. The trials were then condensed into room 330.

Figs. 20-22. 20. Wooden block. 21. Elitech Data Logger. 22. Dead bed bugs from earlier trials

For trials 1-3, bed bugs were counted about every twelve hours. For these initial trials, bed bug mortality was not very high, therefore counting bed bugs was switched to being about every 24 hours. To count bed bugs, the containers were taken out of their respective "moats" and placed on the counter. The lids were taken off and the contents were removed. As the materials were taken out, bed bugs were removed from the treated and untreated material. After bed bugs were examined and classified, the materials were placed back into the container, along with the bed bugs.

When counting, bed bugs were classified as active, inactive, or dead. Active classification constitutes the bed bugs running around or visibly moving multiple legs. The inactive classification is when the bed bugs were barely moving, possibly a leg or antenna twitch. Dead bed bugs were those lying completely still with no movement.

Table 1. For Trials 1-16, dates run, company,, material tested, number of treatments

Trials	Dates	Companies	Types of Textile	Treatments
1	Dec. 13-18	Shaw Industries	carpet binding	2
2	Dec. 13-18	TieTex Industries	skid fabric – large beds	1
3	Dec. 18-28	Layer 1	PVC-silicone	2
4	Dec. 18-28	Preferred Finishing	mattress tape	2
5	Jan. 5-14	TieTex	skid fabric - discs	2 (Slow and Fast)
6	Jan. 5-14	Shaw Industries	carpet binding heavy treated - discs	1
7	Jan. 5-14	Arthoshield	raw arthoshield 880	1
8	Jan. 30 – Feb. 8	TieTex	skid fabric – mini beds	5
9	Feb. 1-10	Preferred Finishing	mattress tape	1
10	Feb. 1-10	Culp	mattress ticking	2 (Hot and Wet)
11	Feb. 10-19	TieTex	skid fabric - mini beds retest	3 (ran out of bugs)
12	Feb. 10-19	TieTex	skid fabric plates	5
13	Apr. 12	TieTex	skid fabric – larger plates	1
14	Apr. 12	Shaw Industries	carpet binding	1
	Apr. 12	Preferred Finishing	arthoshield	1
16	Apr. 14	Duck	weather strip	1

RESULTS

We are just starting to analyze the survivorship between the control and each treatment for each trial. In many of the trials, there is either no difference or only a minor difference between the control and treatment (Figs. 27-28). In several trials there appears to be a difference between the control and treatment (Figs. 27, 29). In a couple trials, there appears to be a significant difference between the control and each treatment (Figs. 23 – 26).

Figs. 23-26 Results for Shaw Carpet Binding (trial 6). Survivorship starting with 10 bed bugs

Figs. 27-29. Results for Culp Mattress Ticking (trial 10). Survivorship starting with 10 bed bugs

DISCUSSION

When testing bed bugs on different textiles, counting them was always a challenge because of how clingy they are to the material and/or materials within the containers, but easy to contain since bed bugs were unable to climb up in the containers that were used for each trial. In the first few trials it was hard to keep track of some of the bed bugs as there were gaps between the glue and the material because they were not glued completely closed. The bed bugs could enter the holes and we were not able to count them or examine their state. Binder clips and wooden blocks were also used in the trails to keep the materials compressed, but many of the bed bugs ending up staying on the wooden blocks or hiding within the clips instead of being on the treated material. This prevented counting all of the bed bugs. The bed bugs that are being used are of different ages, some are not full grown. The smaller immature bed bugs are harder to see than adults because they are often camouflaged on the textile and do not move or are in crevices. The larger plates are working out well for the trials because the bed bugs are staying on the tested material instead of wondering off of the tested material.

ACKNOWLEDGEMENTS

We would like to thank Dan Short and Kyle Bullock of Arthroshield for providing the treated textiles, control textiles, funds for the containers and other supplies needed, as well as the bed bugs. We also thank the Department of Biology and Chemistry for providing lab space in which to conduct these trials.

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Fig. 3-4 Kristian counting bed bugs.