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Capstone Paper

**Introduction**:

The common bedbug, *Cimex lectularius L.*, is a obligate hematophagous parasite of humans in the family Cimicidae. Bed bugs were a common problem in homes until the use of newly developed residual pesticides nearly eradicated the insect in the United States after the 1940s. However, while bedbugs were on the decline in the United States for several decades, they were still a common pest in many other countries, throughout Asia, Africa, and Europe. Infestations by *C. lectularius* in the United States have once more become a prominent issue. The recent resurgence of bedbugs is likely due to travel between infested countries and the United States, the discontinued use of pesticides such as DDT previously used to control bedbugs, and resistances developed by bedbugs to available pesticides. Bed bugs are considered hitch hikers and are often carried back and forth between homes/apartments and places with high human traffic, such as hotels, hospitals, and public transportation. Although they are not known to vector human diseases, bed bugs are a public health concern due to the allergic reaction their bite can cause in humans, and even the psychological stress that an infestation may cause. Because bed bugs were on the decline for several decades in the United states, little research on bed bugs was carried out during that time, and there are significant gaps in our understanding of bed bug biology as a result.

*C. lectularius* is known to have five nymphal instars before becoming a sexually mature adult. Members of this family (Cimicidae) are parasites of vertebrate hosts and must take a blood meal before each molt and before reproduction can take place.

Humans are the preferred host for *C. lectularius*, but other Cimicid species are known to feed on bats and birds. Under laboratory conditions bed bugs will feed on other vertebrate blood sources, but how exactly they make the determination between preferred and non-preferred hosts in the field is currently unknown. In addition, there is little research pertaining to the feeding behaviors of bed bugs, adding to the current gap in our knowledge of bed bug biology. In the case of a human host, the question of whether or not bed bugs can feed through linens and clothing has been raised. To begin to answer this question, we decided to investigate whether or not individuals from a *C. lectularius* laboratory colony that are conditioned to feed through a fabric barrier would feed through different types of fabrics that vary in thickness and weave. *C. lectularius* may not engage in this behavior with any fabric in a natural environment, but the experiment allowed us to test for the *possibility* of feeding through fabric with conditioned insects.

**Methods:**

Hypothesis: If the ability of a bed bug to feed through fabric is related to that fabric's properties, then exposing bed bugs to fabrics with different properties will result in different rates of feeding success.

The bed bugs used for this experiment were obtained from a laboratory colony at Purdue that is conditioned to feed artificially on rabbit blood using the Petri dish method (E. Chin-Heady, unpublished). Both adults and first instar nymphs were tested on each of seven types of fabrics. The artificial feeders consisted of a plastic screw cap jar with the bottom removed and replaced with a test fabric. The colony that test insects were obtained from are reared using an artificial feeding system that requires feeding through a fabric barrier. The weave in this fabric is wide enough for the bed bugs to easily feed, but too small to allow immature bed bugs to escape. The artificial feeder jar can be placed on top of a blood source that has been warmed on a Zoo Med reptile heating pad to allow for feeding. The fabric "organza" which is hot glued to the bottom of the jar on the rearing containers, was used as the control for this experiment.

In order to test the ability of the bed bugs to feed through different fabrics, artificial feeders were constructed with different fabrics adhered to the bottom. For each trial, ten bedbugs were used per replicate and for each of the seven fabrics, there were three replicates. The same 30 adult individuals were used throughout the first feeding test, and all individuals used were male. Males were used to prevent complications that could occur with mixed sexes, such as mating or egg laying. For the second feeding test which involved first instar nymphs, the same 30 nymphs were used without regard to sex. Prior to each day that experiments were conducted, the bedbugs used were deprived of food for approximately 7 days to ensure hunger.

Each of the seven fabrics was examined under a microscope and measurements were taken to determine which fabrics possessed characteristics that may make it difficult to feed through. The fabrics were graded based on tightness of weave and thickness, and the fabrics that would pose a greater challenge to feed through were offered first each day experiments were conducted. During each trial, the bed bugs were allowed to attempt feeding for 15 minutes. At the end of this time, the number of partially fed and fully engorged bed bugs were counted and recorded. In order to ensure that the jars and petri dishes were constructed properly and would not have an effect on the ability of the bed bugs to feed, the three replicates for each fabric were performed in three separate jars and were rotated between three different petri dishes.

**Data**:

Table 1. Fabric measurements

| Fabric Name | Composition | Description | Weave (micrometer) | Thickness (micrometer) |
|---|---|---|---|---|
| Antipill Fleece (blankets/pajamas) | 100% polyester | Densely covered in long fibers; irregular surface; fibers make fabric thicker than length of mouthparts | ~.50 underneath fibers | ~3.7 including fibers |
| Natural Cozy Solid (flannel) | 100% cotton | Densely covered in shorter fibers; slightly irregular surface | .10-.30 underneath fibers | ~.70 including fibers |
| Fuchsia Satin (pajamas) | 97% polyester 3% spandex | Double layer; lightly covered in fibers; surface regular | 0.00 | ~.20 |
| Interlock Knit (tee shirt) | 60% cotton 40% polyester | Tightly woven (no spaces between threads); surface regular | .10 | ~.80 |
| Plant pattern (sheet/pillowcase) | 100% cotton | Lightly covered in fibers; surface regular | 0.01 - 0.29 | ~.20 |
| Crepon Sheer | 100% nylon | Spaces between threads vary in size, surface regular | 0.08 - 0.24 | ~.20 |
| Primrose Organza **(control)** | 100% polyester | Spaces between threads roughly the same size; surface regular | 0.19 - 0.21 | ~.10 |

**Experiment Results:**

**Table 3. Number of Adult Bedbugs Engorged or Partially Fed**

| Fabric | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| Antipill Fleece | - | - | - |
| Natural Cozy Solid | - | - | - |
| Fuchsia Satin | - | - | - |
| Interlock knit | - | - | - |

| | | | |
|---|---|---|---|
| Plant pattern | - | - | - |
| Crepon Sheer | 6 engorged<br>2 partially fed | 2 engorged<br>0 partially fed | 3 engorged<br>2 partially fed |
| Organza<br>(**control**) | 2 engorged<br>1 partially fed | 9 engorged<br>0 partially fed | 3 engorged<br>1 partially fed |

**Table 4. Number of First Instar Nymphs Engorged or Partially Fed**

| Fabric | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| Antipill Fleece | - | - | - |
| Natural Cozy Solid | - | - | - |
| Fuchsia Satin | - | - | - |
| Interlock Knit | - | - | - |
| Plant Pattern | - | - | - |
| Crepon Sheer | 2 engorged | 10 engorged | 7 engorged |
| Organza (**control**) | 7 engorged | 7 engorged | 7 engorged |

**Conclusion:**

Both the adult bed bugs and first instar nymphs were able to feed through the crepon sheer in addition to the control organza fabric. When the two fabrics were compared, it was observed that the spaces created by the weave and the thickness of the fabric were quite similar (refer to Table 1). *C. lectularius* adults were not able to feed through the remaining five fabrics, possibly due to properties unobservable without magnification that may make feeding difficult or impossible, such as the thickness, tightness of weave, or how densely the fabric is covered in fibers. The length of the mouthparts of adult *C. lectularius* were measured to be 0.85 mm, which is sufficient to penetrate the fabric barriers, but they may not be able to probe through the obstacles presented by the fabrics (see Table 2).

The results of the experiment may also be influenced by the behavior of the bed bugs themselves. Although the blood was heated to be similar to human body temperature prior to the experiment, it may have been insulated by the barrier, preventing the bed bugs from detecting the necessary temperature required for feeding stimulation. In the case of the crepon sheer and organza, the spaces in the fabric allow the bed bugs to more readily detect the blood source below. If a certain temperature is required for feeding, direct contact with the skin on warmer spots on the body of a host may be required.

**References**


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