Synthetic Fabrics and Fabric Pests[1, 2]

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J. Entomol. Sci. 26(1): 51-58 (January 1991)

ABSTRACT Larvae of the black carpet beetle, *Attagenus unicolor* (Brahm), the furniture carpet beetle, *Anthrenus flavipes* LeConte, and the webbing clothes moth, *Tineola bisselliella* (Hummel), were exposed to synthetic fabrics contaminated with various stains. Both carpet beetles and the webbing clothes moths damaged synthetic fabrics when stained with such contaminants as alkaline perspiration, catsup, chicken bouillon or 5% sugar solution. Black carpet beetle larvae and webbing clothes moth larvae were more attracted to the contaminated fabrics and caused more damage than furniture carpet beetle larvae.

KEY WORDS Textiles, *Anthrenus flavipes*, *Attagenus unicolor*, *Tineola bisselliella*.

Modern fabrics are composed of many of the older natural fibers such as cotton, linen, silk and wool as well as those made of acetate, acrylic, dacron, nylon, rayon and other synthetic fibers. Also, there are many fabrics made of combinations of natural and synthetic fibers.

Insect damage to wool by larvae of the black carpet beetle, *Attagenus unicolor* (Brahm), the furniture carpet beetle, *Anthrenus flavipes* LeConte, and the webbing clothes moth, *Tineola bisselliella* (Hummel), is well documented. However, very little information is available in the literature concerning the feeding propensities of these pests when they are exposed to synthetic fabrics or other fabrics made of certain natural fibers.

Mallis et al. (1958) showed that no to very slight feeding occurred when larvae of the above fabric insect species were exposed to synthetic fabrics such as dacron, dynel, nylon, rayon and vicara and to natural fiber fabrics such as cotton, linen and silk. However, the above species fed extensively on wool/nylon, wool/orlon and wool/viscose rayon combination fabrics. Bry (1975) and Bry et al. (1982) also showed that larvae of the aforementioned species fed readily on various wool/synthetic blend fabrics; however, microscopic examination of the excrement showed that the synthetic and/or cellulosic fibers passed out of the digestive tract unchanged. This was in agreement with earlier observations by Laibach (1966).

The all synthetic fabrics polyester, dynel and orlon were not damaged by fabric pests in studies conducted by Mallis et al. (1958). However, nylon was not fed on by webbing clothes moth larvae and fed on only slightly by black and furniture

[1] Accepted for publication 24 September 1990.
[2] This paper reflects the results of research only. Mention of a proprietary product does not constitute an endorsement by the USDA.

carpet beetle larvae. Mallis et al. (1959) conducted studies to determine if these fabric pests would feed on polyester, dynel, nylon, and orlon contaminated with stains that made wool very attractive to these pests. These stains were tomato juice, human urine, and human perspiration. Mallis et al. found that the furniture carpet beetle larvae extensively damaged nylon contaminated with all three stains and black carpet beetle larvae only damaged nylon stained with human perspiration. Also, polyester contaminated with tomato juice or human urine was extensively damaged by furniture carpet beetle larvae. Clothes moth larvae were not attracted to any of the stains.

In recent years, several reports were received at this laboratory indicating that fabric insect damage was occurring on many synthetic fabrics. Little, if any, information was available about fabric pests feeding on synthetic fabrics since the earlier work of Mallis et al. (1958, 1959); therefore, we initiated studies with seven synthetic and synthetic combination fabrics to determine their susceptibility to feeding by clothes moths and carpet beetles both before and after the fabric was stained with various contaminants.

Materials and Methods

The seven fabrics used in this study were purchased in a local fabric store and are identified as follows: Fabric 1 contained 100% acetate; fabric 2 contained 50% polyester and 50% acrylic; fabric 3 contained 80% triacetate and 20% nylon; fabric 4 contained 60% rayon, 30% polyester and 10% linen bonded to 100% acetate tricot; fabric 5 contained 50% polyester and 50% rayon; fabric 6 contained 100% nylon and fabric 7 contained 100% polyester. The fabrics were cut into 2.5 - × 5.1-cm samples and a medicine dropper was used to contaminate them with stains by placing three drops of each of the contaminants in the middle of each piece of fabric. The following contaminants were used to stain the fabrics: artificial acid perspiration, artificial alkaline perspiration, catsup, chicken bouillon, mustard and a 5% table sugar solution. The artificial perspiration was formulated according to procedures established by the American Association of Textile Chemists and Colorists (AATCC) (Anon. 1985[a]).

The feeding tests were made with black carpet beetle, furniture carpet beetle, and webbing clothes moth larvae from the laboratory colonies according to the excrement-weight and fabric-weight-loss procedures established for mothproofing tests by the American Association of Textile Chemists and Colorists (AATCC) (Anon. 1985[b]) and the Chemical Specialties Manufacturers Association (CSMA) (Anon. 1971). According to the above procedures, samples exposed to carpet beetles are considered satisfactorily resistant to feeding if the average excrement does not exceed 5.0 mg/sample (0.5 mg/larva), provided no sample in the series exceeds 6.0 mg (0.6 g/larva). A test would be considered invalid if the quantity of excrement deposited on the control samples was less than 15 mg/sample (1.5 mg/larva). Cloth samples exposed to webbing clothes moth larvae are considered satisfactorily resistant to feeding if the average adjusted weight loss of the sample does not exceed 8 mg, provided no single sample in the series exceeded 10 mg loss of weight. A test would be considered invalid if the amount of feeding resulted in less than a 30-mg average loss of weight per control sample.

For this study, each of four 2.5 × 5.1-cm samples cut from each fabric was tested for its susceptibility to feeding damage by black and furniture carpet beetle larvae, and each of four samples was tested against webbing clothes moth larvae by exposing them to 10 larvae for 14 days. These procedures are established for wool and/or other susceptible fibers of animal origin. Therefore, the criteria used for mothproofing tests are not proper in interpreting the data in the current test with all synthetic fibers. A more valid interpretation of the data is a comparison of the excrement weight or weight loss data obtained with the stain-contaminated fabric with that obtained with the uncontaminated fabric. All feeding tests were made in a darkened cabinet in a room maintained at 27 ± 1° C and 60 ± 5% RH. The data were evaluated by analysis of variance and Duncan's multiple range test at the 5% level of probability (Duncan 1955).

Results and Discussion

Results of the feeding tests with black carpet beetle larvae are shown in Table 1. Four of the seven synthetic fabrics were made more susceptible to insect feeding by addition of catsup than by any of the other contaminants. The 100 percent acetate fabric was made highly susceptible to feeding by contaminating it with either catsup or a 5 percent sugar solution. There was no significant difference between the susceptibility to feeding by contaminating the fabric with either of these contaminants. Also, there was no significant difference in the susceptibility of 100 percent nylon fabric contaminated with catsup or a 5 percent sugar solution. The insects generally fed less on the 100 percent polyester fabric and staining with the various contaminants did not make it more susceptible to feeding.

Feeding tests with furniture carpet beetle larvae are shown in Table 2. With the exception of the 100 percent acetate and 50/50 polyester/rayon fabrics, alkaline perspiration made all the other fabrics more susceptible to insect feeding than the other contaminants. There was a low level of feeding on all of the fabrics contaminated by this species. The most feeding occurred on the 100 percent acetate fabric contaminated with catsup. There was no significant difference in the susceptibility of 50/50 polyester/rayon contaminated with either alkaline perspiration or catsup.

Results of the weight-loss tests with webbing clothes moth larvae are shown in Table 3. Five of the fabrics were made more susceptible to feeding by catsup than by any of the other contaminants. Very little feeding occurred on the 50/50 rayon/polyester fabric and there was no significant difference in the feeding susceptibility caused by any of the contaminants. Bouillon on the 100 percent nylon fabric made it significantly more susceptible to feeding than the other contaminants.

No mortality occurred among black carpet beetle larvae exposed to either the unstained or stained synthetic fabrics. There was a low order of mortality among furniture carpet beetle larvae ranging from 0 to 23%. Mortality among webbing clothes moth larvae (Table 4) ranged from 83 to 100% among the larvae exposed to the seven fabrics contaminated with acid perspiration, from 60 to 98% among those exposed to the cloth contaminated with alkaline perspiration and from 55 to 80% among the larvae exposed to all fabrics contaminated with bouillon. No mortality occurred among the larvae exposed to all fabrics contaminated with catsup or mustard and the only mortality among larvae exposed to fabric contaminated with 5% sugar solution was 10% among those larvae exposed to the 100%

Table 1. Average excrement weights (mg/larva) in feeding tests with black carpet beetle larvae exposed 14 days to 2.5- × 5.1-cm synthetic fabric samples contaminated as indicated*, †.

	Synthetic Fabric						
Contaminant	100% Acetate	50/50 Polyester/ acrylic	80/20 Triacetate/ nylon	60/30/10 Rayon/polyester/ linen‡	50/50 Polyester/ rayon	100% Nylon	100% Polyester
Acid perspiration	0.23b	0.12b	0.10c	0.15d	0.13b	0.15b	0.11a
Alkaline perspiration	.30b	.17b	.16b	.31c	.12b	.16b	.11a
Bouillon	.56b	.20b	.10c	.40c	.13b	.22b	.10ab
Catsup	2.07a	.83a	.34a	1.97a	.26a	.44a	.11a
Mustard	.27b	.21b	.16b	.37c	.14b	.17b	.08b
5% Sugar solution	2.45a	.17b	.12bc	.90b	.13b	.39b	.10ab
None	.16b	.19b	.12bc	.22cd	.13b	.18b	.12a

* Data are averages of 4 samples with 10 insects in each.
† Means followed by the same letter in each column are not significantly different (Duncan's Muliple Range Test, P = 0.05).
‡ Bonded to 100% acetate tricot.

Table 2. Average excrement weights (mg/larva) in feeding tests with furniture carpet beetle larvae exposed 14 days to 2.5- × 5.1-cm samples of synthetic fabric contaminated as indicated*, †.

	Synthetic Fabric						
Contaminant	100% Acetate	50/50 Polyester/ acrylic	80/20 Triacetate/ nylon	60/30/10 Rayon/polyester/ linen‡	50/50 Polyester/ rayon	100% Nylon	100% Polyester
Acid perspiration	0.30c	0.24c	0.27ab	0.23b	0.12bc	0.17cd	0.12cd
Alkaline perspiration	.49b	.44a	.35a	.58a	.19a	.33a	.21a
Bouillon	.33c	.22c	.28ab	.28b	.10c	.17cd	.16bc
Catsup	.61a	.21c	.25abc	.30b	.17a	.22bc	.18ab
Mustard	.29cd	.14d	.19bc	.19b	.14b	.17cd	.13bcd
5% Sugar solution	.19d	.19c	.15c	.24b	.10c	.16d	.11cd
None	.29cd	.33b	.29ab	.25b	.11c	.23b	.18ab

* Data are averages of 4 samples with 10 insects in each.

† Means followed by the same letter in each column are not significantly different (Duncan's Muliple Range Test, P = 0.05).

‡ Bonded to 100% acetate tricot.

Table 3. Adjusted weight loss (mg) of snthetic fabric samples exposed 14 days in feeding tests with webbing clothes moth larvae*, †, ‡.

	Synthetic Fabric						
Contaminant	100% Acetate	50/50 Polyester/ acrylic	80/20 Triacetate/ nylon	60/30/10 Rayon/polyester/ linen§	50/50 Polyester/ rayon	100% Nylon	100% Polyester
Acid perspiration	1.07d	0.81bc	1.48cd	-2.04c	-0.07a	1.01b	0.23c
Alkaline perspiration	1.29d	2.18c	.00d	.12c	.14a	1.52b	.58c
Bouillon	2.65cd	.74bc	1.68cd	- .23c	.38a	5.58a	.64c
Catsup	8.23a	4.62a	6.83a	7.53a	.54a	2.58ab	5.91a
Mustard	.88d	.38bc	2.62c	- .02c	- .06a	.63b	.43c
5% Sugar solution	5.30b	1.50ab	4.41b	- .92c	.70a	3.59ab	1.87b
None	3.72bc	2.20ab	1.33cd	4.30b	- .12a	1.14b	.06c

* Data are averages of 4 samples with 10 insects in each.

† Means followed by the same letter in each column are not significantly different (Duncan's Muliple Range Test, P = 0.05).

‡ A figure preceded by a minus sign indicates that the humidity control samples lost more weight during the test period than did the samples exposed to the insects.

§ Bonded to 100% acetate tricot.

Table 4. Mortality (%) among webbing clothes moth larvae exposed 14 days to 2.5 × 5.1-cm samples of synthetic fabrics contaminated as indicated.*

	Synthetic Fabric						
Contaminant	100% Acetate	50/50 Polyester/ acrylic	80/20 Triacetate/ nylon	60/30/10 Rayon/polyester/ linen†	50/50 Polyester/ rayon	100% Nylon	100% Polyester
Acid perspiration	100	100	98	100	100	83	88
Alkaline perspiration	98	90	90	95	88	60	90
Bouillon	60	78	78	80	80	70	55
Catsup	0	0	0	0	0	0	0
Mustard	0	0	0	0	0	0	0
5% Sugar solution	0	0	0	0	0	0	0
None	25	33	25	20	58	72	85

* Data are averages of 4 samples with 10 insects in each.
† Bonded to 100% acetate tricot.

acetate fabric. Mortality among the larvae exposed to the unstained cloth ranged from 20 to 85%.

These studies showed that the webbing clothes moth and black and furniture carpet beetles damage synthetic fiber fabrics when they are contaminated with materials such as alkaline perspiration, catsup, chicken bouillon, or 5% sugar solution. Black carpet beetle larvae and webbing clothes moth larvae were more attracted to the contaminants and caused more damage than did furniture carpet beetle larvae. When a contaminated fabric was slightly or lightly damaged, the damage consisted of a light "grazing" in the contaminated area of the cloth sample. Moderate, heavy and very heavy feeding resulted when holes were eaten through the fabric in the immediate and surrounding area of the contaminant. The number of food and other stains that synthetic fiber fabrics may become contaminated with is legion and the six contaminants used in this study barely scratch the surface of potential contaminants. However, we can conclude from these results that fabric pests will damage soiled synthetic fabrics and the homeowner should take care to place only clean clothing in storage.

Acknowledgments

The author thanks J. H. Lang and G. M. Murray, Stored-Product Insects Research and Development Laboratory, for their assistance in conducting this study.

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