SOME OBSERVATIONS OF THE NUMBER OF BLACK FLIES (DIPTERA, SIMULIIDAE) LANDING ON COLORED CLOTHS

By D. M. Davies

Abstract

The number of black flies alighting on cloths of different colors, each tested with a control of black cloth, varied with the intensity of the light reflected from the cloth and to a lesser extent with the wavelength. Dark blue was the color most frequented followed by dark brown, black, dark green, dark red, medium gray, and white.

Introduction

Insects have long been known to respond differently to light of various colors. Many are attracted more by violet and ultraviolet than by light of other wavelengths (7). Weiss (5, 6), studying many species of insects, found that if the relative energy of different wavelengths was made uniform, the greatest response occurred at 365 millimicrons (ultraviolet) with a smaller peak at 492 mp (blue-green). By changing the intensity of each color, the response of the insect could be made uniform from one color to another. He states in conclusion that "of the two inseparable constituents, wavelength and intensity, the latter seems to be the most important in producing reactions."

It is apparent from experiments with certain mosquitoes and other diptera (1, 2, 4) that many alight more often on dark materials and select blue and violet surfaces rather than those of other colors. However, all diptera do not react in this way (2, 3).

Qualitative observations by the author suggested that black flies land more frequently on dark than on light clothing when it is being worn. However, it was observed also that few flies landed on dark cloth that was off the body, even when the cloth had been soaked in human and artificial perspiration. It seemed important, therefore, to determine the number of black flies landing on black and white cloths and also on those of different colors while they were on the human body.

Methods

The study proceeded from June 27 to July 5, 1947, in Algonquin Park, Ontario. Tests were made on cloths having the following Munsell color notations: dark blue (8.5 PB 1.8/3.0), dark brown (1.5 YR 2.0/1.8), black N 1.2/yellowish), dark green (1BG 2.0/1), dark red (6 R 2.3/9), medium gray (N 5.1/), and white (N9+/), the black being a control in all tests.

In each test the black cloth and one of the other colors were laid side by side on the observer's leg, the black being the closer to the body in approxi-
mately half the tests. The black flies alighting on the two adjacent 6 in. square areas of these cloths, shaded from the direct sunlight, were counted simultaneously during intervals of two minutes.

The intensity of the total light reflected from each cloth (the reflectance) was measured with a "Weston Master" exposure meter (model 715). The reading of this meter represents approximately a visual intensity factor because the meter has a light sensitivity similar to that of the human eye and is more sensitive to the blue region of the spectrum. The change in intensity of reflected light from 400-750 m\(\mu\) was recorded for each cloth with a recording spectrophotometer* using a standardized opaque, white vitrolite glass plate as control. For lower wavelengths (230-405 m\(\mu\)) reflectances from the cloths were compared by a "Bellingham and Stanley" spectrophotograph, using as the light source a mercury-arc, direct current, quartzite lamp from which a high proportion of the radiation was ultraviolet. The spectrum of the reflected light was recorded in a 10 min. exposure on an orthochromatic, photographic plate.

Results

The identification of black flies, collected immediately before or after the tests, indicated that over 90% were Simulium venustum Say.

A black cloth was used as a control in each test as the tests were made on different days and the number and activity of the flies at the station might differ. However, when two cloths are placed side by side it may be that the color of one cloth may influence the number landing on the other. It has seemed advisable, therefore, to consider the number of flies landing on the test cloth as a percentage of the total number landing on both it and the control (Table I) rather than to compare the number landing on the color to

<table>
<thead>
<tr>
<th>Color</th>
<th>Number of tests</th>
<th>Total number landing on cloths</th>
<th>Landing percentage</th>
<th>Reflectance ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Colored</td>
<td>Black control</td>
<td>(Color/Total x 100)</td>
</tr>
<tr>
<td>Dark blue</td>
<td>12</td>
<td>346</td>
<td>82</td>
<td>81.3</td>
</tr>
<tr>
<td>&quot; brown</td>
<td>10</td>
<td>81</td>
<td>34</td>
<td>70.5</td>
</tr>
<tr>
<td>&quot; green</td>
<td>7</td>
<td>44</td>
<td>54</td>
<td>44.9</td>
</tr>
<tr>
<td>&quot; red</td>
<td>10</td>
<td>19</td>
<td>43</td>
<td>30.6</td>
</tr>
<tr>
<td>Med. gray</td>
<td>13</td>
<td>86</td>
<td>231</td>
<td>27.1</td>
</tr>
<tr>
<td>White</td>
<td>26</td>
<td>52</td>
<td>634</td>
<td>7.6</td>
</tr>
<tr>
<td>Black</td>
<td>78</td>
<td>—</td>
<td>—</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* Measurements were made through the courtesy of the Photometry and Colorimetry Laboratories, Optics Section, National Research Council of Canada.
the number landing on the black control. This is referred to as the landing percentage. The data on which the percentages are based are plotted in Fig. 1. The square roots of the numbers were used in the figure, as is usually done with this type of data, to make the variance more uniform.

![Diagram](Can_J_Zool-000-c.png)

**Fig. 1.** The square root of the number of black flies landing on a 6 in. square of each colored test cloth plotted against the square root of the total number landing on adjacent 6 in. squares of the test cloth and the black control cloth during an interval of two minutes. The straight line passes from the origin through the arithmetic mean.

The lowest landing percentage was obtained with white cloth and the highest with the dark materials, medium gray being intermediate (Table I). The landing percentage for the dark materials varied from color to color decreasing in this order: blue, brown, green, and red. In the tests with the black and green cloths the number landing on both was about equal, with that for the black being a little higher.

The total reflectances of the colored cloths, as measured by the exposure meter and as calculated from the areas under the spectrophotometric curves (correcting for scale differences), were each divided by that for the black cloth recorded at the same time (Table I). These ratios are referred to as the reflectance ratios. The reflectance ratios derived from the spectrophotometric readings are only a little higher than those derived from the readings...
of the exposure meter, except in the case of the red cloth which is over four times the value. The cloths with the lowest landing percentages, white and gray, had the highest reflectance ratios. Little difference was found between the reflectance ratios of the various dark cloths (except in the case of the ratio of the spectrophotometric readings for the red which also had the lowest landing percentage of the dark cloths), although the landing percentages were distinctly different.

The intensities of all wavelengths of light reflected from the black control cloth, as measured by the spectrophotometer, are almost equal (Fig. 2). The reflectances of the gray and the other dark cloths have a high red component (Fig. 2) but the blue cloth has also a high blue component. The curve for white rises gradually in intensity from 400-750 mµ.

If the intensity of reflected light from 400-460 mµ for the dark cloths, as calculated from the areas under the curves, is considered (Table II) the values decrease from blue, through brown, green, and black, to red. This is the reverse of the sequence of values for the landing percentages, except for green and black which are almost equal in reflectance and in the number of flies landing on them. The white and gray cloths with low landing percentages have much higher reflectances than the other cloths in this range of wavelengths.
FIG. 3.—Spectrograms of the reflection from colored cloths exposed for 10 min. to the light of a mercury-arc, quartzite lamp.
FIG. 4.—Spectrograms as in Fig. 3 but with the slit narrowed to show the individual bands in the white (c) for comparison with the blue (a) and black (b) and for labelling the bands.
TABLE II

Areas under curves for each wavelength interval as an index of intensity of reflected light (each value is corrected for interval and scale differences and divided by the value for the black control).

<table>
<thead>
<tr>
<th>Color</th>
<th>Wavelength in m(\mu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>400-460</td>
</tr>
<tr>
<td>Dark blue</td>
<td>3.59</td>
</tr>
<tr>
<td>Dark brown</td>
<td>1.57</td>
</tr>
<tr>
<td>Black</td>
<td>1.00</td>
</tr>
<tr>
<td>Dark green</td>
<td>1.08</td>
</tr>
<tr>
<td>Dark red</td>
<td>0.774</td>
</tr>
<tr>
<td>Medium gray</td>
<td>8.68</td>
</tr>
<tr>
<td>White</td>
<td>31.9</td>
</tr>
</tbody>
</table>

The reflectance of all wavelengths from 230-405 m\(\mu\) was greater for the white and gray cloths than for the dark cloths as shown by the spectrograms (Figs. 3a-g, 4a-c). The spectrograms for the dark cloths (Figs. 3a-e, 4a, b) record the fact that the greatest reflectance of ultraviolet and violet wavelengths occurred with blue cloth; brown, black, red, and green cloths showed respectively decreasing reflectances in these wavelengths. The dark cloths with the highest reflectances of ultraviolet and violet wavelengths had the highest landing percentages.

A few black flies landed on each of the cloths but they frequented some more than others. The number of black flies alighting on a cloth was influenced more by the intensity than by the wavelength of the reflected light. Few flies landed if the total intensity of the light reflected from the cloths was high and more flies landed when intensity was low. When the total intensity of the reflected light was similar the highest landing percentages were obtained with cloths having the highest intensity in the blue to ultraviolet region of the reflected light.

Thus the wearing of white clothing would be desirable where black flies of the species S. venustum are common. On the other hand dark clothing, particularly blue, would be the least desirable.

Acknowledgments

Sincere thanks are extended to Dr. H. B. Speakman, Director, Ontario Research Foundation, who encouraged and provided the opportunity for this research. The interest and counsel of Prof. F. F. Ide, University of Toronto, Dr. A. M. Fallis, Ontario Research Foundation, and Dr. D. H. Hamly of the University and the statistical advice of Dr. D. B. Delury of the Foundation is gratefully acknowledged. I wish to thank Prof. K. B. Jackson of the University for providing facilities and advice in spectroanalysis and Prof. R. R. Langford, Ontario Fisheries Research Laboratories, for facilities in studying the black flies during the summer.
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