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BEHAVIORAL RESPONSE OF *MUSCA DOMESTICA* TO VISUAL TARGETS

GORO KIMURA
Technical Research Laboratory, Ikari Shodoku Co., Ltd., 1–12–3 Akanehama, Narashino, Chiba 275–0024, Japan

Abstract In this study, we investigated the effectiveness of visual cues of sticky sheets for capturing house flies . In addition, we also examined the insect catching ability of LED-UV light traps under the same conditions. There was no significant difference between the number captured on the sticky sheets with visual cues (randomly printed fly illustrations, regularly placed black spots, and regularly placed real house flies) and plain sticky sheets. The capture efficiency of the sticky sheet was not affected by the presence of a similar size to the flies or by the presence of individual flies. The light trap was found to be more effective than sticky sheets with or without visual cues for efficient monitoring.

Key words visual cue, sticky sheet, LED-UV light trap, monitoring, integrated pest management

INTRODUCTION

The house fly, Musca domestica, is the most common and widespread species of fly in the world. House flies are often found in abundance in areas with human activities such as hospitals, food markets, slaughter houses, food courts or restaurants, poultry and livestock farms where they constitute a nuisance to humans, poultry, livestock and other farm animals, and also act as potential vector of diseases (Awache et al., 2016). They are also responsible for massive economic damage to businesses operating in the food industry, such as in the agriculture, livestock and poultry industries, because they contaminate products and transmit a wide range of pathogens to humans and animals (Carolyn, 1998).

From an integrated pest management (IPM) perspective, each facility should strive to maintain adult house fly numbers below a measurable abundance threshold (“action threshold”), above which nuisance or pathogen transmission to nearby humans and animals may occur (Gerry et al., 2011). An empirically determined action threshold will differ for each facility according to site-specific factors, including the design and operation of the facility, characteristics of the surrounding environment, distance to nearby homes and schools, and people’s tolerance to flies in the surrounding area. In addition, the action threshold can differ depending on the fly monitoring method selected and the specific placement of individual traps or devices used (Gerry, 2020).

Methods for monitoring house fly abundance in enclosed poultry houses have been developed, such as sticky ribbons, spot cards, and baited traps (Anderson and Poorbaugh 1964; Axtell, 1970; Burg and Axtell 1984; Gerry, 2020). Musca domestica responds to visual cues on the sticky sheet if a resource is associated with the contrasting patterns. House flies commonly land near and pounce on other flies or fly-sized dark objects. They are also known to exhibit edge detection and orientate towards edges (Wehrhahn, 1984; Conlon and Bell, 1991). This information suggests that increasing the visual complexity of traps with fly mimics or contrasting

edges may facilitate capturing M. domestica. However, the effectiveness of these visual effects on house flies has yet to be determined in situ. This study reinvestigated the effectiveness of the presence or absence of target visual cues . In addition, we also examined the insect catching ability of LED-UV light traps under the same conditions.

MATERIALS AND METHODS

Three types of interactive visual cues were examined: regularly spaced black fly mimics, black spots and fly individuals. The spots were circular, self-adhesive, black paper stickers, 8 mm in diameter. The black spots and fly individuals were affixed to the yellow sticky sheet (Ogata hochuban, Ikari Shodoku Co., Ltd.). The fly mimics were randomly printed on commercially available yellow-green sticky sheets (Patarin sheet, SC Environmental Science Co., Ltd.). Various tests were combined into a two-part test. Each sheet was set in two corners of the room at a height of 1.5 m from the floor. The test was repeated four times, with the position of each adhesive sheet being swapped for each test.

The house flies were automatically counted and collected by a light trap equipped with two 20-W UV-LED lamps (Clean Eco Line GXII Web, IKARI Shodoku. Co., Ltd.) and hung on the wall 1.5 m above the floor. Each test was repeated three times for each lighting condition.

All investigations were carried out in the behavioral experimental room (16 m^2 with a volume of 43.2 m^3), maintained at 25 ± 0.5 °C, L:D=0:24 or L:D=24:0. The room was sealed using an airtight door to prevent flies from escaping.

All data analyses were conducted using the software KyPlot 6.0 (KyensLab Inc., Tokyo, Japan).

RESULTS AND DISCUSSION

The average number of individuals captured on the sticky sheets with randomly printed fly illustrations was 30.0 ± 10.9 ind., and the number captured on the plain sticky sheets was 31.5 ± 9.9 ind. (Figure 1). The average insect capture rate for the two sticky sheets combined in this test was 61.5 ± 19.1 %. There was no significant difference between the number captured on the randomly printed sticky sheets and those captured on the plain sticky sheets under the light conditions (*t* test, $p>0.05$). The average number of individuals captured on the sticky sheets with randomly printed fly illustrations was 26.0 ± 2.4 ind., while the number captured on the plain sticky sheets was 21.8 ± 3.5 ind. under the dark conditions. There was no significant difference between the number captured on the randomly printed sticky sheets and those captured on the plain sticky sheets (*t* test, $p>0.05$). The average capture rate under dark conditions was 47.8 ± 4.7 %, which is lower than that under light conditions.

The average number of individuals captured on the sticky sheets with regularly placed black spots was 29.0 ± 10.9, while the number captured on the plain sticky sheets was 31.3 ± 2.1 under the light condition (Figure 2). The average insect capture rate for the two sticky sheets combined in this test was 60.3 ± 10.2%. There was no significant difference between the number of flies captured on the sticky sheets with regularly placed black spots and those captured on the plain adhesive sheets (*t* test, $p>0.05$). The average number of individuals captured on the sticky sheets with regularly placed black spots was 7.5 ± 1.3, and the number captured on the plain sticky sheets was 11.3 ± 3.9 under the dark condition. There was no significant difference between the number captured on the sticky sheets with regularly placed black spots and those

captured on plain adhesive sheets (*t* test, $p>0.05$). The average capture rate under dark conditions was 18.8 ± 5.0%, which was a significantly decrease compared with that under light conditions (*t* test, $p<0.01$).

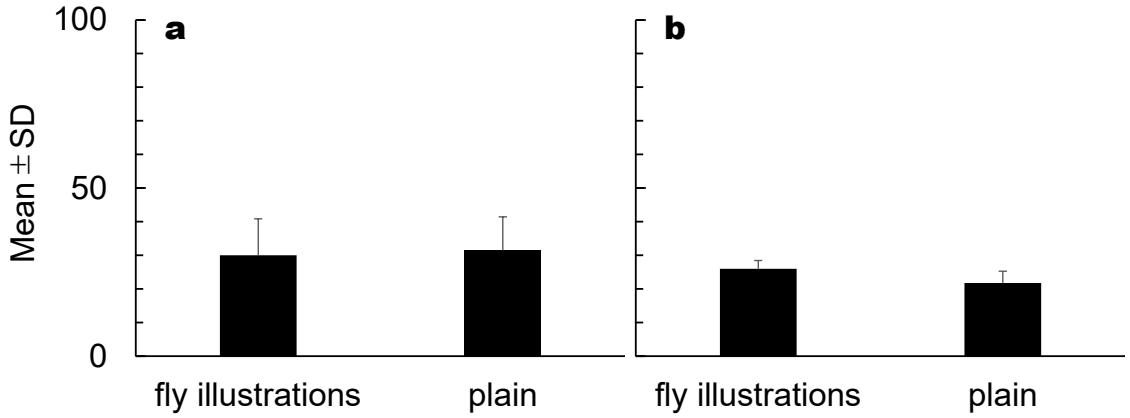

Figure 1. Mean percent of house flies that responded to sticky sheets with randomly printed fly illustrations and plain sticky sheets. a: light condition, b: dark condition. Error bars represent standard deviation of the mean ($N = 4$).

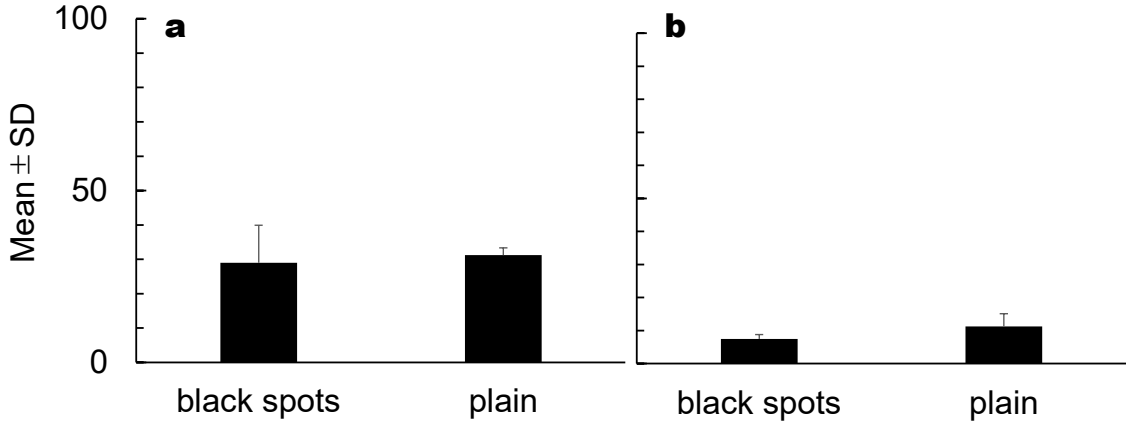

Figure 2. Mean percent of house flies that responded to sticky sheets with regularly placed black spots and plain sticky sheets. a: light condition, b: dark condition. Error bars represent standard deviation of the mean ($N = 4$).

The average number of individuals captured on the sticky sheets with regularly placed real house flies was 29.8 ± 11.2, and that on the plain sticky sheets was 29.3 ± 13.6 under the dark condition (Figure 3). Regularly placed real house flies also did not attract any flies (*t* test, $p>0.05$). The average number of individuals captured on the sticky sheets with regularly placed real house flies was 17.8 ± 4.6, while the number captured on the plain sticky sheets was 8.8 ± 3.9 under the dark conditions. There was a significant difference between the number captured on the sticky sheets with regularly placed real house flies and plain adhesive sheets (*t* test, $p<0.05$). The average insect capture rate for the two sticky sheets combined under the light and

dark conditions were 59.0 ± 11.2% and 26.5 ± 1.3%, respectively. The average capture rate under dark conditions was significantly decreased compared with that under light conditions (*t* test, $p<0.01$). These results suggest that while real houseflies are not attracted by visual cues, they may be attracted by non-visual cues such as odor. These attraction effects are weaker than visual cues, and no synergistic effects with visual cues are expected.

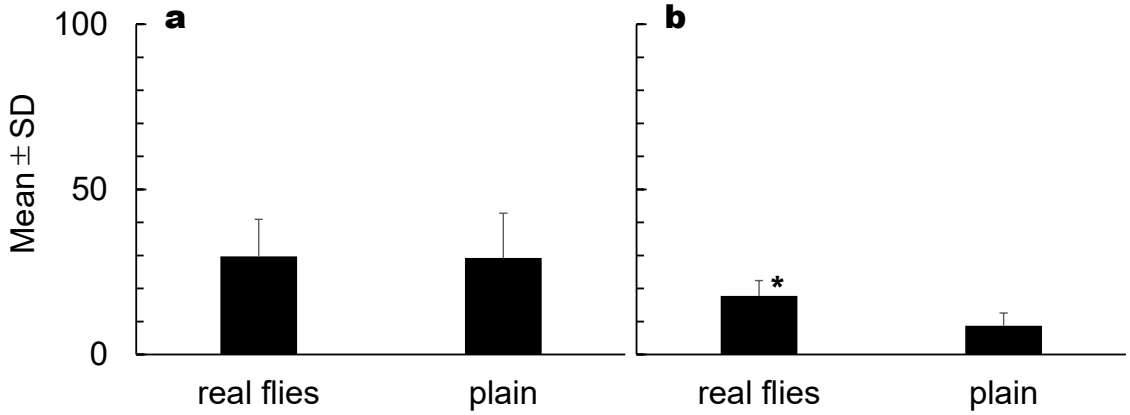

Figure 3. Mean percent of house flies that responded to sticky sheets with regularly placed real house flies and plain sticky sheets. a: light condition, b: dark condition. Error bars represent standard deviation of the mean. The asterisk indicates a significant difference between the two groups (*t*-test; $p < 0.05$; $N = 4$).

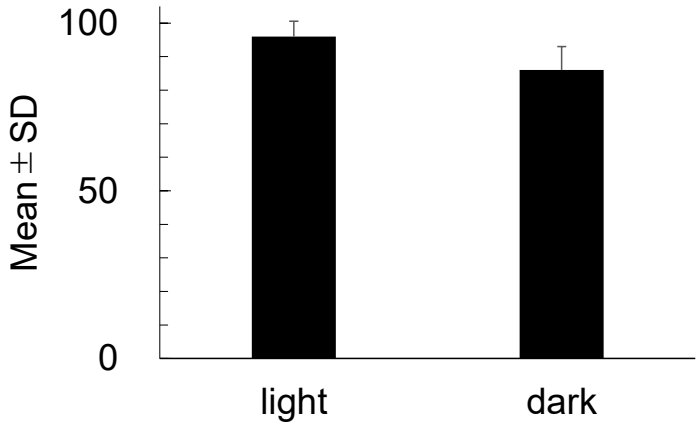

Figure 4. Mean percent of house flies that responded to light traps under the light and dark conditions. Error bars represent standard deviation of the mean.

The mean capture rates of house flies of under the light and dark conditions were 96.0 ± 4.6% and 86.0 ± 7.0%, respectively (Figure 4). There was no significant difference between the number captured under light conditions and those captured under dark conditions (*t* test, $p>0.05$). This study clarified that the capture ability of the light trap was only minimally affected by light

and dark conditions. Under the dark conditions, the light traps collected over 50% of the insects at 180 minutes after release and over 90% at 390 minutes after release (Figure 5). In contrast, under the light conditions, the light traps collected over 50% of the insects at 60 minutes after release and over 90% at 150 minutes after release. The average capture time under dark was slower than that under light conditions.

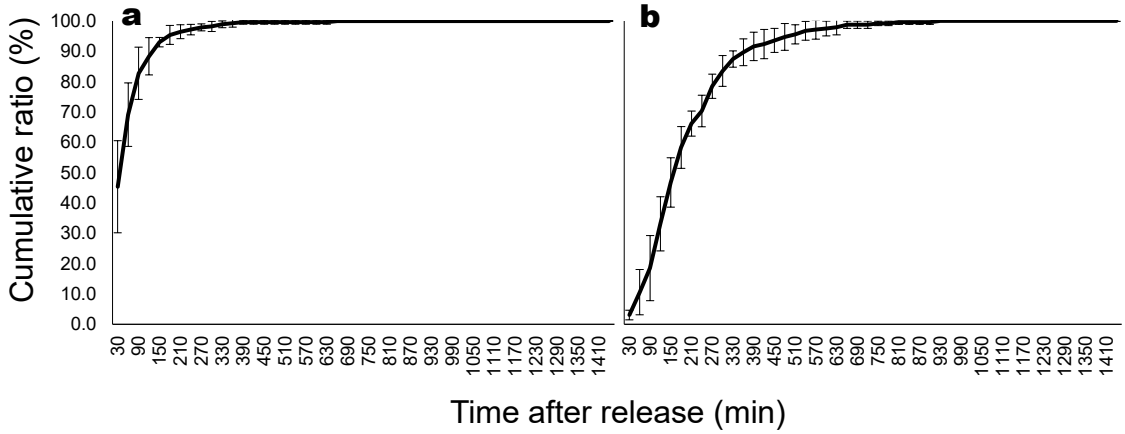

Figure 5. Mean cumulative catch rates of house flies in the light trap. a: light condition, b: dark condition. Error bars represent standard deviation of the mean.

While any of the numerous commercially available sticky fly traps can be used for fly monitoring, these traps have generally not been tested for efficacy as fly capturing or monitoring devices (Gerry, 2020). Sticky traps are optimal in outdoor locations as they can more effectively withstand the outdoor environment, though dusty conditions can hinder their use (Kaufman et al., 2001). Our results suggest that the light trap is more effective than sticky sheets with or without visual cues for efficient monitoring. Light traps have been deployed to controlled flies in homes and restaurants, but such devices rely on a power source, which may not be available in a resource-poor setting (Jones et al., 2024). The capture efficiency of the sticky sheet is not affected by the presence of shapes a similar size to the flies or by the presence of individual flies. The results of this study indicate that house flies do not land near or attack other flies or black objects the same size as flies. In the future, we aim to continue our research by focusing on black objects which are fly-sized or larger.

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