

COMPARISON OF NUMBER OF *LIMNOPHYES NATALENSIS* (DIPTERA: CHIRONOMIDAE) COLLECTED WITH STICKY AND SUCTION LIGHT TRAPS IN FOOD FACTORY

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Abstract Adult *Limnophyes natalensis* were collected using sticky and suction light traps during the course of a year in a Japanese food factory. Such physical control methods have been demonstrated effective for collecting adult midges. The numbers of adult *L. natalensis* collected with the two methods were compared by season. A total of 121 were collected over eight nights with the sticky light trap, and 194 were collected with the suction light trap, a significantly higher number. The numbers were not significantly different for winter. These results demonstrate that suction light traps are more effective for collecting adult midges in food factories.

Key words Chironomid midges, nuisance, physical control, sticky light trap, suction light trap

INTRODUCTION

Although Chironomidae are not listed as a household pest as are Diptera (Ito, 1982), adult chironomids can contaminate materials and final products in pharmaceutical and food processing factories (Tabaru et al., 1987). While they typically originate outdoors (e.g., Matsuzaki and Buei, 1993; Hattori and Moriya, 1996).

Colonization and massive numbers of *Limnophyes natalensis* (Kieffer) in Japanese food factories have been reported (Kimura et al., 2010, 2014). Genus *Limnophyes* is terrestrial and semi-terrestrial (Pinder, 1995), and *L. natalensis* have been reported to breed in rivers and streams (Sæther, 1990). An investigation at a certain food factory discovered *L. natalensis* larva in the organic residue from the drains and machines (Kimura, unpublished). Kimura et al. (2014) used a special light trap to investigate the abundance and flight activity of adult *L. natalensis* in a food factory and found that the thermal conditions affected both on a daily basis (Kimura et al., 2014).

While chemical insecticides are frequently used to control midge population, biological and physical control methods have also been used (Failla et al., 2015). Methods for controlling *L. natalensis* have not yet been established, because chemical control has been avoided in Japanese pharmaceutical and food factories, and biological control is not realistic in such environments. A more promising approach to controlling the adult *L. natalensis* population is to use light traps because this species exhibits phototactic behavior (Kimura et al., 2014).

In the study reported here, we compared the effectiveness of using sticky and suction light traps in a food factory as an ecological approach to the effective physical control of *L. natalensis*.

MATERIALS AND METHODS

Study Site

The food factory is in Chiba City, Chiba Prefecture, Japan and usually operates from 08:00 to 18:00. The lights are normally off from 18:00 to 08:00. Data on the seasonal abundance and flight behavior of *L. natalensis* in this factory were given by Kimura et al. (2014).

Collection of *L. natalensis*

The sticky light trap (Optclean VI, Ikari Shodoku Co., Ltd.) was equipped with a 20-W black fluorescent lamp (Figure 1), the suction light trap (Clean Eco Line GXmini, Ikari Shodoku Co., Ltd.) equipped with two 10-W black fluorescent lamps (Figure 2). Both were installed 1.0 m above the floor, with a distance of 5.0 m between them. They were operated from 17:00 to 8:00 over the course of a year (2013), and their locations were switched at the start of each sampling period: spring (March 19–20 and 21–22; vernal equinox on March 20), summer (June 20–21 and 21–22; summer solstice on June 21), autumn (September 21–22 and 22–23; autumnal equinox on September 23), and winter (December 21–22 and 22–23; winter solstice on December 22). The sticky sheet and insect net were replaced after each sampling period.

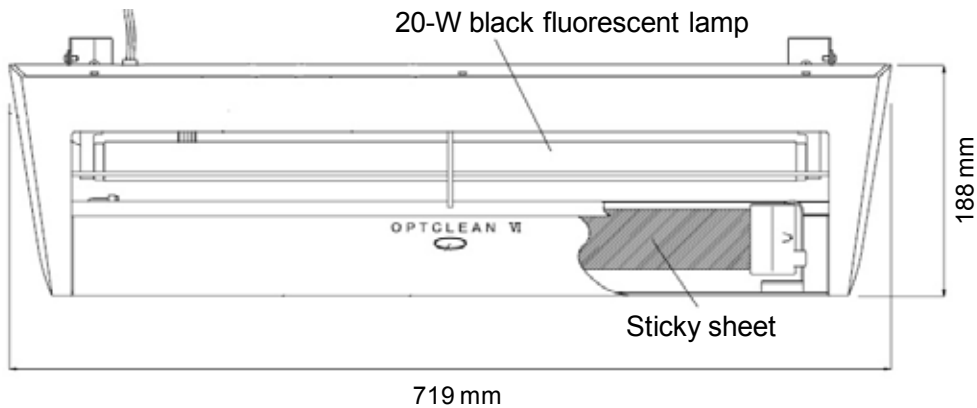


Figure 1. Structure of sticky light trap.

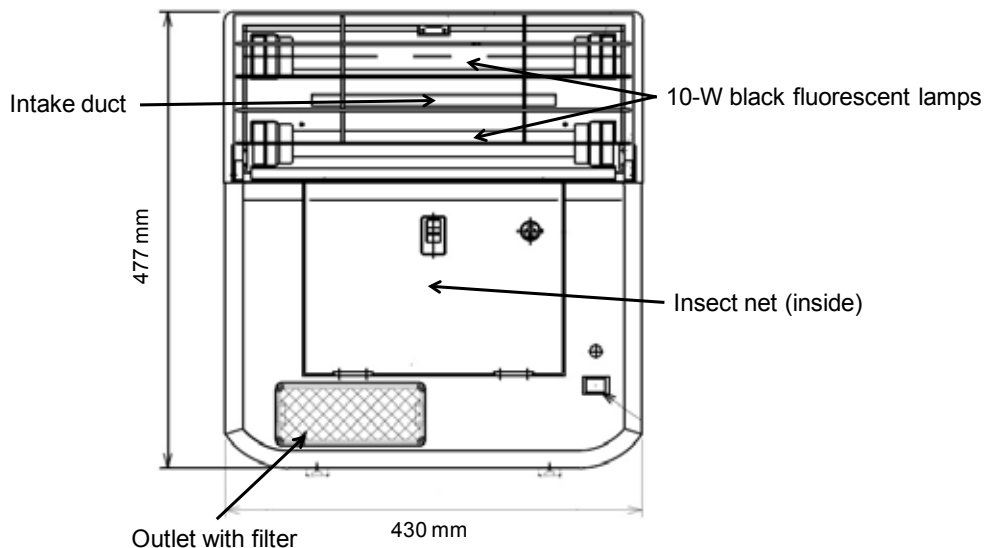


Figure 2. Structure of suction light trap.

Room air temperature was continuously measured with a temperature and humidity sensor (TH-001, Ikari Shodoku Co., Ltd.) each sampling period. The mean room air temperature ranged from $13.1 \pm 6.8^\circ\text{C}$ (December 21–23) to $19.5 \pm 0.7^\circ\text{C}$ (June 20–22), averaging $17.2 \pm 4.6^\circ\text{C}$. The mean air temperature during the early morning hours (4:00–8:00) did not fall below 7.4°C at any time (Figure 3). The *L. natalensis* were counted using a binocular dissecting microscope.

Data analysis

All statistical tests were performed using SPSS version 11.5.1.J for Windows (SPSS Japan Inc.).

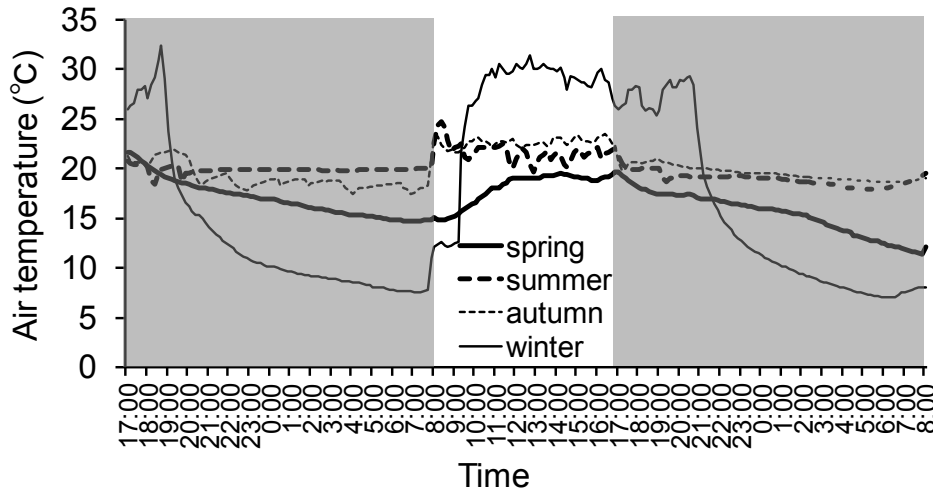


Figure 3. Air temperature in food factory by season. Shaded areas indicate times light traps were in operation.

RESULTS AND DISCUSSION

A total of 121 (male:female=78:43) adult *L. natalensis* were collected during the sampling periods with the sticky light trap, 194 (123:71) were collected with the suction light trap (Table 1). The sex ratio was biased towards male for each trap. The number collected with by suction light trap was significantly higher than the number collected with the sticky light trap (Binomial test, $p < 0.01$). The number was the highest for summer (sticky light trap: 68/collected over two nights; suction light trap: 95/collected over two nights), followed by autumn (34 and 54), spring (13 and 32), and winter (6 and 13). The number collected with the suction light trap was significantly higher for each season (Binomial test, spring: $p < 0.01$; summer and autumn: $p < 0.05$), except for winter (Table 1).

As mentioned above, the thermal conditions affect the abundance and flight activity of adult *L. natalensis* on a daily basis. Adult *L. natalensis* were collected in the morning, when the mean air temperature was higher than 7.4°C (Kimura et al., 2014). Therefore, the daily flight activity of *L. natalensis* showed two peaks (morning and evening) from spring to autumn, with only an evening peak in winter (Kimura et al., 2014), which agrees with the low number collect in winter.

These results demonstrate that suction light traps are more effective than sticky light traps for collecting adult midges in food factories. However, sticky light traps have been traditionally used in Japanese food factories because the sticky sheets prevent dispersal of insect debris and reduce insect contamination. The suction light trap used in this study has become widely used in Japanese food factories as a means of physical control because it is equipped with a filter to control the dispersal of insect debris (Figure 2).

Table 1. Number of adult *L. natalensis* collected using suction and sticky light traps.

Sampling period (17:00–8:00)	Suction light trap			Sticky light trap		
	M	F	Total	M	F	Total
March 19–20	8	1	32 ^A	8	1	13 ^a
March 20–21	20	3		3	1	
June 20–21	29	32	95 ^B	23	12	68 ^b
June 21–22	17	17		16	17	
September 21–22	8	1	54 ^B	16	7	34 ^b
September 22–23	29	16		8	3	
December 21–22	8	0	13	4	2	6
December 22–23	4	1		0	0	
Total	123	71	194^A	78	43	121^a

Aa, Bb: Values with different superscript in same row are significantly different in binomial test (Aa: $p < 0.01$; Bb: $p < 0.05$)

It has been shown that the attraction of chironomid species to a light source is directly proportional to light intensity (Ali et al., 1984, 1986; Hirabayashi et al., 1993). The suction light trap (Clean Eco Line GX, Ikari Shodoku Co., Ltd.) we used has a powerful light source two 20-W black fluorescent lamps. This trap has been widely used in Japanese food factories as a means of physical control. The chironomid species responded more to the quantity of light than to the quality of light (Ali et al., 1984, 1986; Hirabayashi et al., 1993). There is little information about their attraction to the visible light of a LED. Kimura et al. (2014) demonstrated that chironomid midges are equally attracted to a white fluorescent lamp (emitting UV light) and a white LED lamp (not emitting UV light). Hirabayashi et al. (2016) reported that chironomid midges are attracted to several colors of LEDs, with a green LED being the most attractive, followed by a white fluorescent lamp, white LED, UV LED, red LED, and blue LED. Further research on the manipulation of wavelength should be undertaken to obtain a better understanding of how chironomid midges can be effectively controlled in food factories.

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