



## Effect of visible light sticks for collecting of adult caddisflies (Trichoptera): A preliminary field study

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### Abstract

Local residents along the Uji River, Kyoto, Japan, may be exposed to seasonal invasions of adult caddisflies. Ultraviolet (UV)-blocking materials are believed to be an effective pest management tool because adult caddisflies are often attracted to light sources that emit large amounts of UV light. To clarify the effect of the visible spectrum, we collected adult caddisflies using blue, green, and yellow light sticks that did not emit UV light. Traps were operated from 18:30 (sunset: 18:22) on September 2, 2016 to 06:00 (sunrise, 05:31) on September 3, 2016. We collected 382 adults representing eight species of caddisflies. Green light sticks attracted the most numerous individuals (189 adults, seven species), followed by blue (134 adults, seven species), then yellow (59 adults, five species). *Paduniella tanidai* Nishimoto was the dominant species (331 adults). These results suggest that adult caddisflies are attracted not only to the UV spectrum but also the visible spectrum.

**Keywords:** near-UV light, nuisance, *Paduniella tanidai*, pest management

### Introduction

Trichoptera eyes are highly sensitive to near-ultraviolet (UV) light radiation (Mikkola, 1972) and vision in the UV range is important for orientation in many species. Faunistic and ecological studies in Trichoptera frequently use black light (UV) traps (e.g., Waringer 1989, 1991, 2003; Nozaki & Gytoku 1990; Nishimoto & Nishimoto 1993; Kimura *et al.* 2006; Kimura & Hirabayashi 2008), and occasionally mercury vapor lamps (Nozaki 1988; Nishimoto & Nishimoto 1997) and daylight fluorescent lamps (Kimura *et al.* 2008, 2011; Hirabayashi *et al.* 2011).

The mass emergence of adult aquatic insects often causes a severe nuisance, such as disruption of business, poor visibility, traffic problems, and foul odor (Munroe 1951; Peterson 1952; Osgood 1957; Fredeen 1972). Furthermore, Parlato (1929) identified the hairy wing of caddisfly as an inhalant allergen worldwide. Local residents along the Uji River, Kyoto, Japan, are exposed to seasonal invasions of adult caddisflies, especially hydropsychid species (Kobayashi & Takemon 2014). However, chemical control of Trichoptera is not economically feasible and has undesirable impacts on other riverine organisms. Therefore, the development of physical and biological control strategies is required along the Uji River.

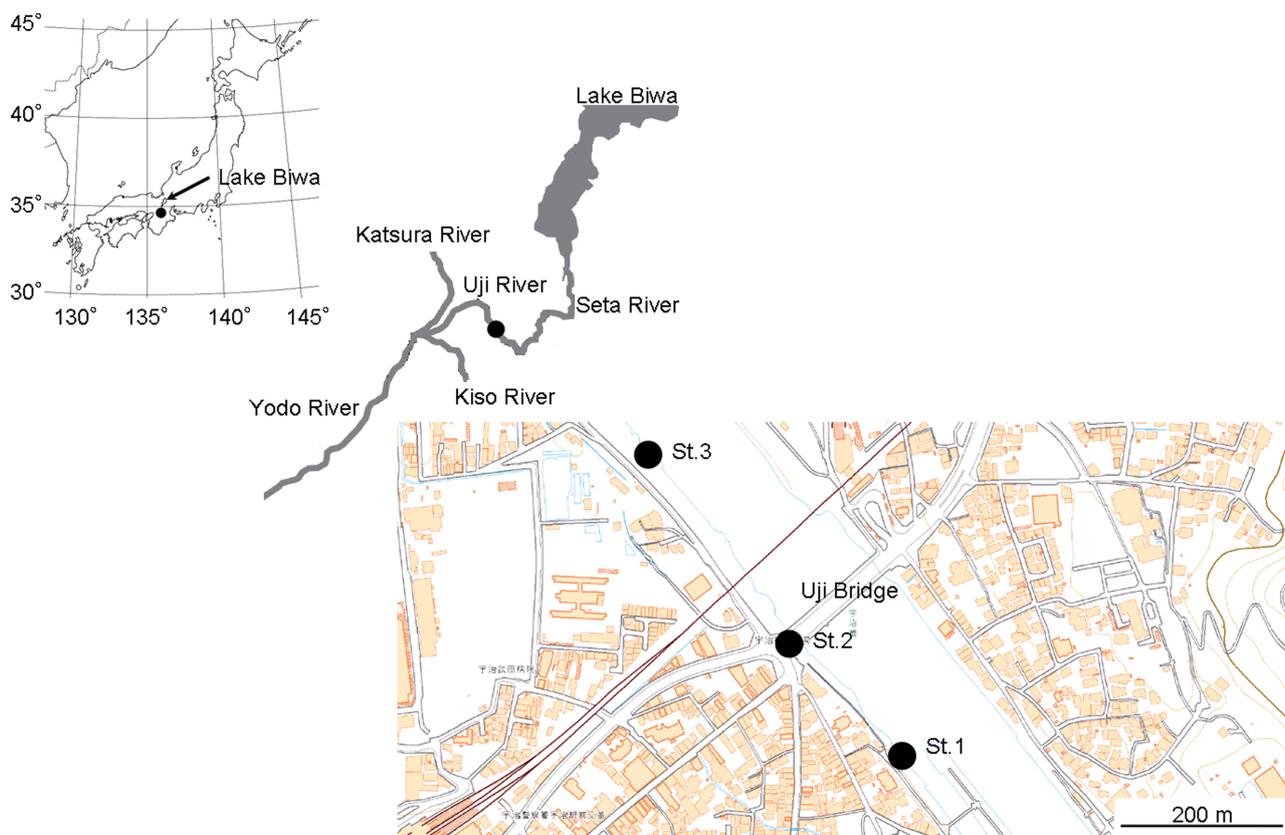
The use of UV-absorbing materials that block near-UV light radiation has been shown to be effective in preventing different types of pests from entering buildings such as houses and factories. However, Kimura *et al.* (2014) reported that adult Trichoptera were attracted not only to a white fluorescent lamp (emitting near-UV spectrum) but also a white light emitting diode (LED) lamp (not emitting near-UV spectrum).

Light sticks use energy generated from a chemical reaction to emit light. When the plastic stick is bent, it breaks open a glass vial, and two solutions are mixed together. The chemicals immediately react with one another, starting a chemical reaction that emits light. The articular color dye used in the chemical solution gives

the light with a distinctive color. To clarify the effect of light not emitting near-UV spectrum, we collected Trichoptera adults using three colors of light sticks.

## Materials and Methods

The present study was conducted at three sampling sites (St.1, St.2, and St.3) near the Uji Bridge in the floodplain of the Uji River, Kyoto Prefecture, Japan (Fig. 1). The annual average maximum and minimum water temperature around the Uji Bridge is  $28.9 \pm 1.4 \text{ C}^\circ$  and  $5.4 \pm 1.4 \text{ C}^\circ$ , respectively (Kobayashi & Takemon 2014). In addition, total nitrogen and total phosphorus around the Uji Bridge is 0.5 g/L and 0.025 g/L, respectively (Kobayashi *et al.*, 2017). For each of three traps at each of the three stations, one light stick (Glowing Light Stick, Daiso Industries Co., Ltd.; 15 cm in length, 2 cm in thickness) was mounted 10 cm over the center of a tray (26 cm  $\times$  35 cm  $\times$  5 cm) that was half filled with foaming soap (Mousse Aid Sol Pro, Ikari Shodoku Co., Ltd.) (Fig. 2). Three colors (blue, green, and yellow) of light sticks with pan traps were used at each station. Each light pan trap with its respective color of light stick was set at ground level and was situated approximately 0.5 m from the water edge. The blue, green, and yellow light-stick traps were located about 10 m apart from each other at each station. The spectrum of the light sticks was measured 1 min after breaking using a spectrophotometer (USB2000, Ocean Optics Inc., Largo, USA) with an attached sensor fiber placed 0 cm in front of a light stick. None of the chemical light sticks emitted near-UV spectrum (Fig. 3). The blue, green, and yellow light sticks had peaks at 458, 527, and 570 nm, respectively. The pan traps were operated from 18:30 (sunset at 18:22 on September 2, 2016) to 06:00 (sunrise at 5:31 on September 3, 2016). Adult caddisflies were separated from the other insects. The adults were identified according to the taxonomic keys of Tanida *et al.* (2005), and individual numbers of each species were counted under a binocular dissecting microscope in the laboratory. In order to compare the Trichoptera fauna among the light sticks, we calculated the Shannon-Wiener diversity index ( $H'$ ).



**FIGURE 1.** Locations of sampling sites.



**FIGURE 2.** Light stick pan trap. The pan was filled with mousse that was for catching and killing adult caddisflies. The light stick was fixed at the center of the pan at a height of about 10 cm.

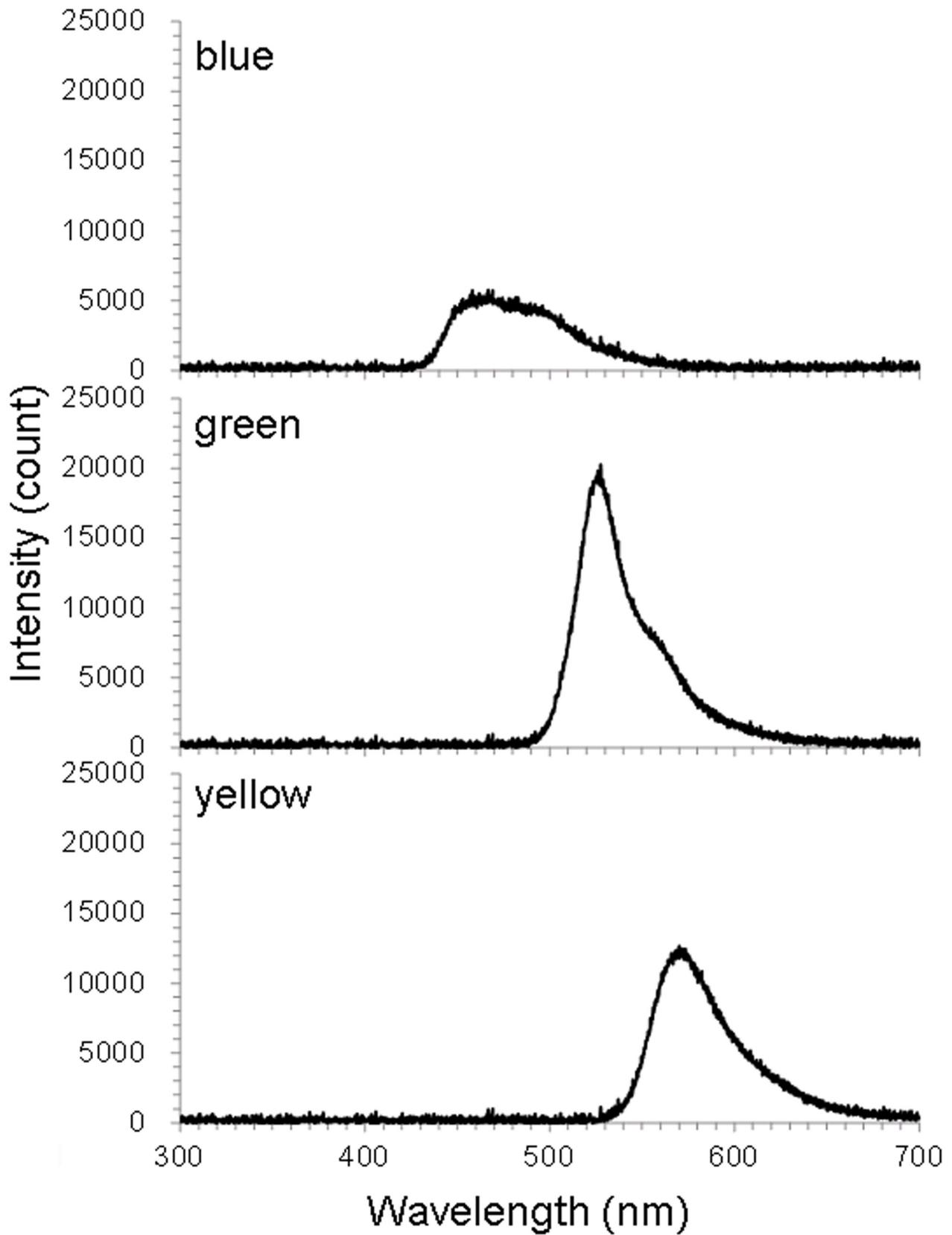
## Results

A total of 382 (313 males, 69 females) adult Trichoptera were trapped (TABLE 1). We identified eight species in the present study. Seven species were collected using blue and green sticks, and five species were collected with the yellow sticks. *Paduniella tanidai* Nishimoto 2011 was the most abundant species (331 individuals; 283 males, 48 females; 86.6% of total Trichoptera), followed by *Hydroptila phenianica* Botosaneanu 1970 (20 individuals; 10 males, 10 females; 5.2% of total Trichoptera). The green light sticks collected the most *P. tanidai* individuals (164 individuals; 141 males, 23 females), followed by the blue sticks (116 individuals; 101 males, 15 females), and the yellow sticks (51 individuals; 41 males, 10 females). *Paduniella tanidai*, *H. phenianica*, *Ecnomus tenellus* Rambur 1842, *Hydropsyche setensis* Iwata 1927, and *Trichosetodes japonicus* Tsuda 1942 were common to all light sticks. On the other hand, a few adults of *Psychomyia* sp. and *Oecetis antennata* (Martynov, 1935) were collected with only green or blue lights, respectively. The Shannon-Wiener diversity index ( $H'$ ) was highest for blue (0.88), followed by green (0.86) and yellow (0.81) lights.

## Discussion

Our results suggest that Trichoptera respond not only to the UV spectrum but also to the visible spectrum. In particular, the green and blue spectra may be useful for attracting adult Trichoptera. In the sister order of Trichoptera, yellow illumination has been used effectively to control the activity of nocturnal moths and thus

reduce damage to fruit, vegetables, and flowers (Shimoda & Honda 2013). Based on results of the present study, the yellow spectrum may be able to control adult Trichoptera activity.



**FIGURE 3.** Relative spectral distribution of the three light sticks.

**TABLE 1.** Trichoptera adults collected by three colors of light sticks beside the Uji River, Kyoto, Japan on 2–3 September 2016. M = males, F = females.

	St. 1						St. 2						St. 3						Total					
	blue		green		yellow		blue		green		yellow		blue		green		yellow		blue		green		yellow	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
<i>Hydroptila phentanica</i>	2	1	3	1	1	2	1	2	1	2	1	1	2	2	1	1	3	3	6	4	1	3	10	10
<i>Paduniella tamidai</i>	38	5	21	4	18	5	5	1	11	3	1	58	9	109	16	23	4	101	15	141	23	41	10	283
<i>Psychomyia</i> sp. ( <i>acutipennis</i> sensu Tsuda)							1					1						1						1
<i>Ecnomus tenellus</i>							1					1		1		1		2		1		1		4
<i>Cheumatopsyche brevilineata</i>							1	1	1	1		3	1	1	1		3	1	1	1	1		4	2
<i>Hydropsyche setensis</i>								2	1			1		3				1		5	1	1		7
<i>Oecetis antennata</i>								2	1											2	1			2
<i>Trichosetodes japonicus</i>							2	2	3	2		2	2	3				2	2	3		2	2	7
Total	40	6	24	5	20	7	8	4	17	11	0	65	11	115	17	24	5	113	21	156	33	44	15	313
Species	2	2	3	3	3	3	4	6	6	2	2	6	4	4	3	3	3	7	7	7	5	5	8	8
Diversity index ( $H'$ )	0.35	0.58	0.73	0.73	0.73	0.73	1.63	2.15	2.15	0.92	0.92	0.78	0.38	0.43	0.43	0.43	0.43	0.88	0.86	0.86	0.81	0.81	0.89	0.89

*Paduniella tanidai* was the dominant species in this study. On the other hand, hydropsychid species was subordinate in this study. The present study suggests that blocking near-UV light radiation may not to be effective in preventing attraction of *P. tanidai*.

Light traps are a powerful sampling method and are useful for faunistic and ecological investigations. In aquatic insects, this method is especially useful for Trichoptera, although other groups such as Diptera (especially Chironomidae) and Ephemeroptera (especially Caenidae) are also often caught in large numbers (Waringer 1989, 2003). In general, light traps require an electric power supply. Price and Baker (2016) demonstrated the feasibility of using small, lightweight, and inexpensive LED-based light traps for studying the biodiversity of aquatic insects in remote locations. On the other hand, light sticks use energy from a chemical reaction to emit light and radiate various wavelengths. These results suggest that light sticks are a useful source of light traps for investigations of Trichoptera.

The sex ratio of the adult Trichoptera, especially of *P. tanidai*, was male-biased during the study period. Previous reports found female-biased sex ratios of caddisflies in light trap samples (Nishimoto & Nishimoto 1993; Kimura *et al.* 2008). A female bias may reflect actual larval sex ratios in the river or may be attributed to the light trap selectivity of sexes. The sex ratios of larval populations in the river could not be clarified and compared in the present study.

The most serious pest at Uji River is a hydropsychid species, *Macrostemum radiatum* (McLachlan 1872), which was not collected in this study. *Macrostemum radiatum* was attracted to blue sticks at the same time in 2017, and it was suggest that this species were present in 2016 but was not caught by chance.

The present study was conducted during only one summer night; therefore, further follow-up field investigations are necessary to collect more adults using light sticks. Such additional investigations may improve our understanding of trichopteran phototaxis, including that of hydropsychid species.

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