Proceedings of the Sixth International Conference on Urban Pests
William H Robinson and Dániel Bajomi (editors), 2008
Printed by OOK-Press Kft., H-8200 Veszprém, Pápai út 37/a, Hungary

SEASONAL ABUNDANCE OF ADULT CADDISFLY (TRICHOPTERA) IN THE MIDDLE REACHES OF THE SHINANO RIVER IN CENTRAL JAPAN

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Abstract Mass emergences of adult caddisflies often lead to severe nuisance conditions. The objective of this study is to clarify the abundance and seasonal trend of adult caddisflies in the middle reaches of the Shinano River. All of the adult caddisflies attracted to the illuminated showcase of a vending machine set along the river were collected with an insect aspirator from 20:00 to 20:20 (20 minutes), every night from March 28 to December 1 in 2006. A total of 2,930 adult caddisflies was collected from May 1 to November 10. The daily abundance of the total adults reached a maximum on September 2 (291 individuals / 20 minutes / m^2). We identified a total of 15 species belonging to 12 genera of 10 families. The sex ratio of the adult caddisflies was female-biased during the study period. The most abundant family was Psychomyiidae (83.1%), followed by Hydropsychidae (11.2%) and Hydroptilidae (1.7%). The highest number of species among the families was found in Hydropsychidae (5 species), followed by Psychomyiidae (2 species). The most abundant species was *Psychomyia acutipennis* (83.1%), followed by *Hydropsyche orientalis* (5.8%) and *Hydropsyche setensis* (2.8%). *P. acutipennis* adults were collected from mid-May to late October and its daily abundance showed two peaks. Adult hydropsychid species were collected from early May to early November. *H. setensis* was collected from May to September, and its seasonal abundance showed two peaks. *Cheumatopsyche brevilineata*, *Cheumatopsyche infascia* and *H. orientalis* were collected from May to October, and each of their daily abundance showed one peak. *Potamyia chinensis* was collected from May to October. There were significant correlations between the daily abundance of total caddisflies and daily mean air temperature. No adult caddisflies were collected on the days when the daily mean air temperature was less than 10.7°C.
Key Words hydropsychid species, *Psychomyia acutipennis*, seasonal abundance

INTRODUCTION

Trichoptera, or caddisflies, one of the largest groups of aquatic insects, are holometabolous insects with aquatic larvae and pupae and terrestrial adults (Wiggins and Currie, 2007). The order name Trichoptera is derived from the Latin meaning “hair-wing,” referring to the hair covering on the wings of the adults (Wiggins, 1996). Since Parlato (1929), the hairy wing of caddisfly is known as an inhalant allergen throughout the world. Because the larvae of caddisflies are usually abundant in freshwater, mass emergence of the adults often leads to severe nuisance conditions i.e., obstruction of business, poor visibility, traffic mess, and very foul odor (Munroe, 1951; Peterson, 1952; Osgood, 1957; Fredeen, 1972).
The Shinano River runs through urban, agricultural and mountain areas. Although there have been revious reports on the abundance of caddisfly larvae in the middle reaches of the Shinano River (Hirabayashi et l., 2004), few have focused on the abundance of adult caddisflies in this river to date.

In the present study, we investigated the species composition, abundance and seasonal trend of adult Trichoptera assemblage throughout a year, in order to clarify the present situation in the middle reaches of the Shinano River.

MATERIALS AND METHODS

Study Site

The Shinano River is the longest river in Japan (length 367 km; drainage area 11,900 km^2). It runs through Nagano and Niigata Prefectures and flows north, eventually into the Japan Sea. The study site is located in the middle reaches of the Shinano River (5th order section; altitude 450 m; 36°23′N, 138°15′E), and is

surrounded by the urban area of Ueda City with its total population of 167,000 (Figure 1). The riverine habitat consisting of 'unit structures' of a natural river system, i.e., scour pools, riffles and runs, has been generally well preserved. The riverbed substrate of the river is largely composed of loose rocks, and the channel width about 25 m. Some artificial structures that protect the riverbank from erosion have been constructed along the river.

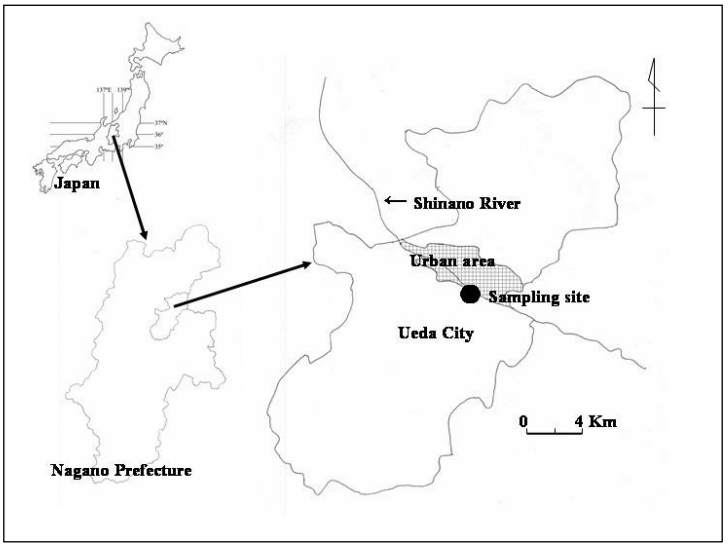

Figure 1. Map of the study site.

Collection of Adults

Light traps are often used in faunistic investigations of adult caddisflies in adjacent aquatic habitats, because the adults are strongly attracted to light (Waringer, 1989). In the present study, we used vending machine (DyDo DRINCO Inc.) equipped with three 32-W daylight fluorescent lamps (FL32SEX-D-HG, NEC Corp.) as a simple light trap method (Kobayashi, 2001). The illuminated showcase of the vending machine (85 × 110 cm^2) was set one meter above the ground level. The vending machine was set in a causeway along the river and situated approximately 150 m from the water edge. There was no other artificial light between the water edge and vending machine. Because the daily flight time of Trichoptera is from sunset to before midnight (Katoh and Ohgushi, 1959), the collection time include part of the daily flight time. All of the adult caddisflies attracted to the illuminated area of the vending machine were collected with an insect aspirator for 20 minutes every night (from 20:00 to 20:20) from March 28 to December 1 (249 nights) in 2006. All caddisfles were identified under a binocular microscope using mainly the taxonomical keys provided by Tanida et al. (2005) and stored in 70% ethanol. Daily mean air temperature measured at Ueda Weather Station during the study periods (Japan Meteorological Agency, 2006) was used for the meteorological data.

Collection of Larvae

Caddisfly larvae were collected monthly in riffles with a Surber sampler (30 × 30 cm^2, 450 μm-meshe) from April to December in 2006. In the laboratory, the larvae species were identified under a binocular microscope using mainly the taxonomical keys provided by Tanida et al. (2005) and stored in 70% ethanol.

Data Analysis

The statistical significance of the Pearson correlation coefficients between the daily mean air temperature and the daily abundance of adult caddisfly (total catch, dominant and hydropsychid species) was tested using a computer program package (SPSS Japan Inc., 2002) on a day-by-day basis (n = 249).

RESULTS

The daily mean air temperature ranged from 0.6°C (March 30) to 27.9°C (August 18 and 19), averaging 16.9 ± 6.5°C during the study period (Figure 2).

A total of 2,930 adult caddisflies were collected in the study period (Table 1). Adult caddisflies were collected from May 1 (air temperature, 18.5°C) to November 10 (12.8°C), although no adults were collected on the day when daily mean air temperature was lower than 10.7°C. The daily abundance of adults reached a maximum on September 2 (291 ind. / 20 min. / m^2; 22.2°C).

We identified a total of 15 adult species and 8 species of larvae belonging to 12 genera of 10 families (Table 1). Psychomyiidae (83.1% of the total abundance) was the most abundant family, followed by Hydropsychidae (11.2%) and Hydroptilidae (1.7%). The highest number of species among the families was found in Hydropsychidae (5 species belonging to 3 genera), followed by Psychomyiidae (2 species belonging to 1 genus). The most abundant species was *Psychomyia acutipennis* (Ulmer, 1908) (2,434 individuals, 83.1%), followed by *Hydropsyche orientalis* Martynov, 1934 (170 individuals, 5.8%), and *Hydropsyche setensis* Iwata, 1927 (81 individuals, 2.8%). The sex ratio of the total caddisfly assemblage was female-biased during the study period due to the high abundance of females of the two major species, i.e., *P. acutipennis* and *H. orientalis* (Table 1).

Adult *P. acutipennis* was collected from mid-May to late October and the daily abundance showed two peaks, the first from late May to late July (max. 99 ind. / 20 min. / m2; 18.1°C on May 28) and the second from late August to early September (max. 284 ind. / 20 min. / m2 on September 2) (Figure 2). Adult hydropsychid species were collected from early May to early November. On September 9 (air temperature, 25.7°C), the largest numbers of hydropsychid caddisflies (21 ind. / 20 min. / m2) were collected during the sampling periods. *H. setensis* was collected from May to September. The latter had one peak in early July (maximum number, 5 individuals / 20 min / m2; air temperature, 22.2°C in July 4) that was clearly separated from the other peak in late August (max. 5 ind. / 20 min. / m2; 23.0°C on August 31). *Cheumatopsyche brevilineata* (Iwata, 1927), *Cheumatopsyche infascia* Martynov, 1934 and *H. orientalis* were collected from May to October, and each of their seasonal abundance showed one peak, i.e., on September 20 for *C. brevilineata* (max. 4 ind. / 20 min. / m^2; 22.9°C), on August 20 for *C. infascia* (max. 5 ind. / 20 min. / m^2; 27.7°C) and in September for *H. orientalis* (max 14 ind. / 20 min. / m^2; 25.7°C on September 9 and 19.1°C on September 30). *Potamyia chinensis* (Ulmer, 1915) was collected from May to October and seasonal change of this species showed no clear peak.

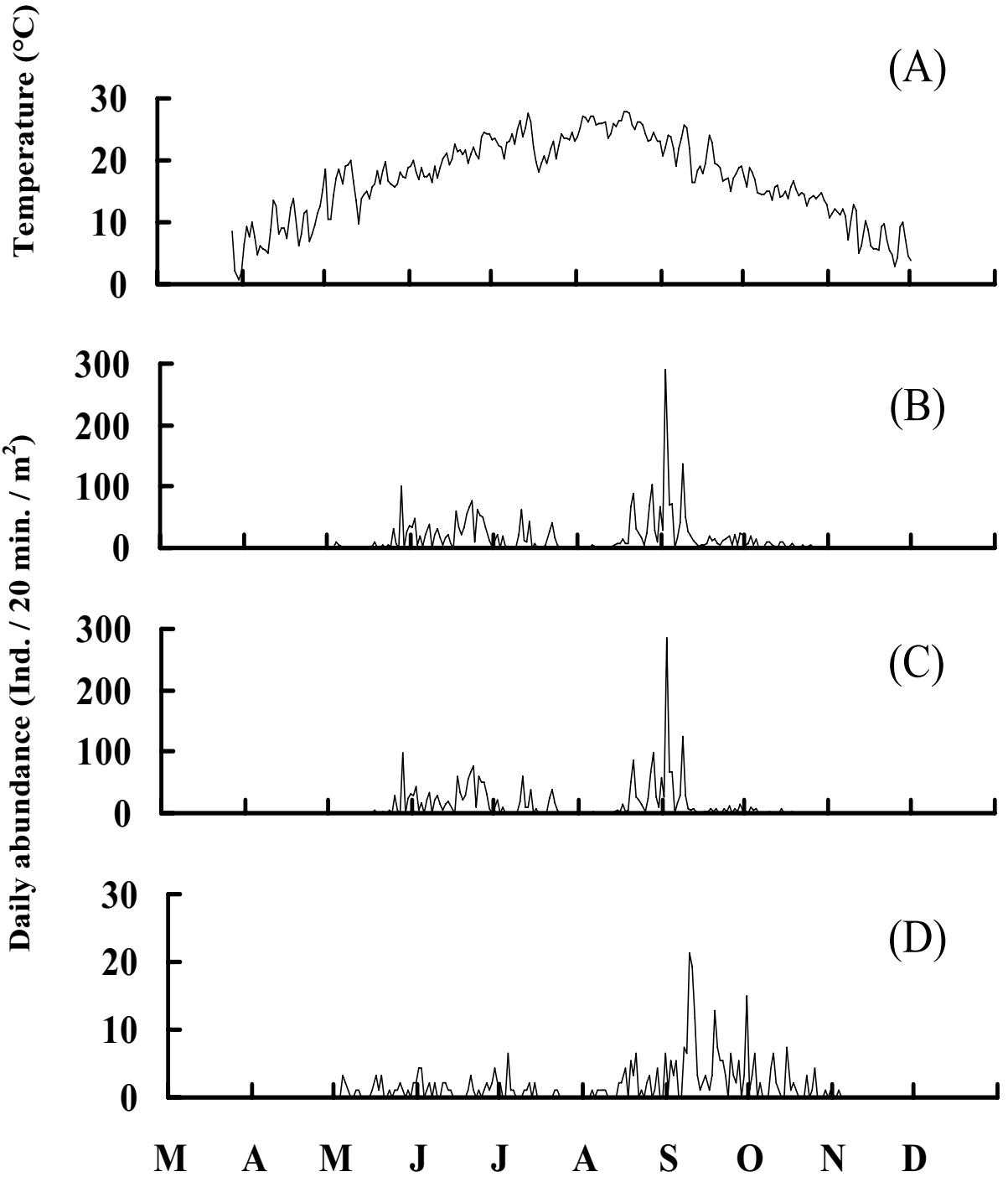

Figure 2. Meteorological parameters and daily abundance of Trichoptera (= number of Trichoptera caught per 20 minutes) at the study site; showing (A) values of mean air temperature (°C), (B) total, (C) dominant species (*P. acutipennis*), (D) all hydropsychid species.

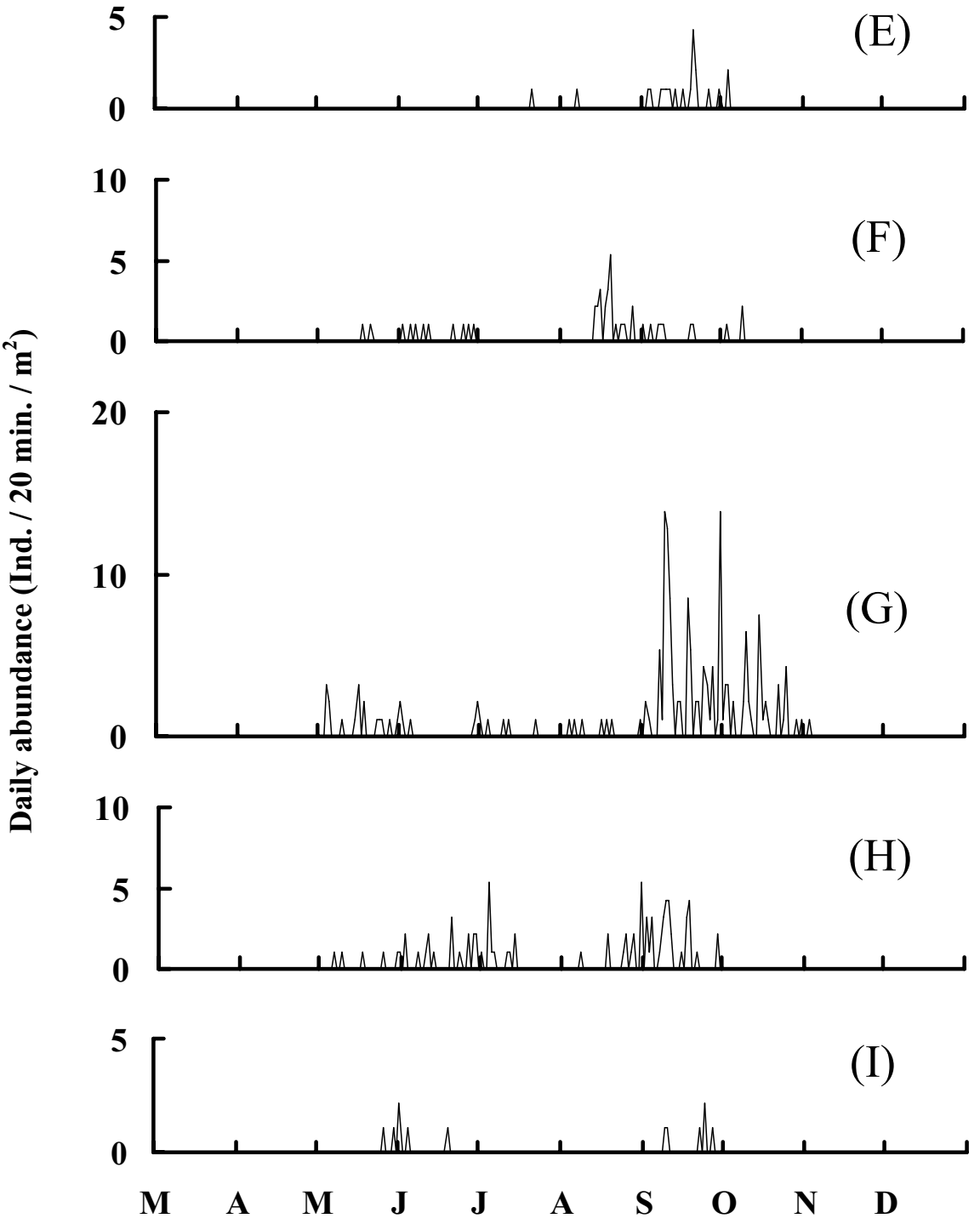

Figure 2 (Continued). Daily abundance of Trichoptera (= number of Trichoptera caught per 20 minutes) at the study site; showing (E) *C. brevilineata*, (F) *C. infascia*, (G) *H. orientalis*, (H) *H. setensis*, and (I) *P. chinensis*.

Table 1. Caddisflies collected in the middle reaches of the Shinano River.

	Vending machine					Larval sampling
	n	males /females	% F	%	Temporal distribution	
Rhyacophilidae						
Rhyacophila yamanakensis Iwata, 1927	12	7/5	41.7	0.4	30 May - 5 Oct.	○
Hydroptilidae						
Hydroptila matsuii Kobayashi, 1974	49	15/34	69.4	1.7	30 May - 10 Nov.	
Glossosomatidae						
Padunia sp.	1	0/1	100.0	0.03	18 Jun.	
Psychomyiidae						
Psychomyia acutipennis (Ulmer, 1908)	2434	726/1708	70.2	83.1	17 May - 29 Oct.	○
Psychomyia sp.	1	0/1	100.0	0.03	8 Sep.	
Stenopsychidae						
Stenospyche marmorata Nava ş 1920	80	49/31	38.8	2.7	1 May - 1 Nov.	○
Hydropsychidae						
Cheumatopsyche brevilineata (Iwata, 1927)	21	4/17	81.0	0.7	21 Jul. - 3 Oct.	○
C. infascia Martynov, 1934	43	13/30	69.8	1.5	18 May - 9 Oct.	○
Hydropsyche orientalis Martynov, 1934	170	28/142	83.5	5.8	4 May - 3 Nov.	○
H. setensis Iwata, 1927	81	59/22	27.2	2.8	6 May - 29 Sep.	○
Potamyia chinensis (Ulmer, 1915)	12	11/1	8.3	0.4	26 May - 27 Sep.	○
Limnephilidae						
Nothopsyche ulmeri Schmid, 1952	1	1/0	0.0	0.03	19 Oct.	
Apataniidae						
Apatania aberrans (Martynov, 1933)	7	1/6	85.7	0.2	9 Oct. - 21 Oct.	
Goeridae						
Goera japonica Banks, 1906	17	9/8	47.1	0.6	18 May - 9 Oct.	
Leptoceridae						
Setodes argentatus Matsumura, 1907	1	1/0	0.0	0.03	7 Aug.	
No. of specimens	2930	924/2006	68.5	100.0	1 May - 10 Nov.	
No. of families	10					4
No. of genera	12					6
No. of spcies	15					8

There were significant correlations between the daily abundance of total caddisflies and daily mean air temperature ($r = 0.342$, $p < 0.001$). In addition, the daily abundance of *P. acutipennis* ($r = 0.313$, $p < 0.001$), *C. brevilineata* ($r = 0.132$, $p = 0.037$), *C. infascia* ($r = 0.309$, $p < 0.001$), *H. orientalis* ($r = 0.159$, $p = 0.012$), and *H. setensis* ($r = 0.321$, $p < 0.001$) showed significant correlations with daily mean air temperature. However, there were no significant correlations between the daily abundance of *P. chinensis* ($p = 0.294$) and the daily mean air temperature

DISCUSSION

In the present study, the great numbers of adult *P. acutipennis* and hydropsychid species were captured on the illuminated showcase of vending machine. In addition, their larvae were also collected in riffles in the middle reaches of the Shinano River, suggesting that massive numbers of adults emerged in the river were attracted to the light of the vending machines.

Psychomyia acutipennis and hydropsychid species are widely distributed in Japan (Tanida et al. 2005), and *P. acutipennis* has been known to dominate in the Kamo River, Kyoto (Tsuda, 1942). In addition, the two hydropsychid species, *H. orientalis* and *C. brevilineata*, were reported to dominate in the Hakusan region (Tanida, 1982), Chikushino City (Nozaki and Gyotoku 1990), and Sakuragata (Nishimoto and Nishimoto, 1993). *P. acutipennis* adults appeared from May to November in the Kamo River (Tsuda, 1942). Moreover, adults of *H. orientalis* and *C. brevilineata* appeared from May to October throughout Japan (Tsuda, 1942; Tanida, 1982; Nozaki, 1988, Nishimoto and Nishimoto, 1993). As for *C. brevilineata*, Nozaki and Gyotoku (1990) and Kimura et al. (2006) reported that seasonal abundance of this species showed no clear peak. The flight periods of *P. acutipennis*, *H. orientalis* and *C. brevilineata* were almost the same between the middle reaches of the Shinano River and other regions.

In the present study, the daily mean air temperature showed significant correlations with the daily

abundance of adult *P. acutipennis* and hydropsychid species. Flight activity of an adult caddisfly is strongly influenced by seasonal conditions (Kiss and Schmera, 1997; Schmera, 2002). Especially, air temperature is one of the most important factors in fight activity (Johnson, 1969).

The sex ratio of the adult *P. acutipennis* and hydropsychid species was female-biased during the study period. Previous reports also found female-biased sex ratios of caddisflies in light trap samples (e.g., Tsuda and Kawai, 1956; Tanida, 1982; Nishimoto and Nishimoto, 1993). The female bias may reflect actual larval sex ratios in the river, or may be attributed to the light trap selectivity of sexes, although the sex ratios of larval populations in the rivers could not be clarified in the present study.

In light of the results mentioned above, it was suggested that local residents along the middle reaches of the Shinano River may be exposed to periodic invasions of adult *P. acutipennis* and hydropsychid species. Therefore, the development of physical and biological control strategies is needed along the middle reaches of this river. Based on the present results, keeping the windows closed and turning off the lights of rooms facing the river in massive flight seasons, i.e., early September, may be the best way for the local residents to prevent the nuisance.

ACKNOWLEDGEMENTS

We are very grateful to Tezuka Manufacturing Co. Ltd. personnel for allowing us to collect samples from their works. We would like to thank Mr. D. Toyoda and Mr. K. Masada, and colleagues at the Department of Applied Biology, Shinshu University, for their generous support and assistance during the investigation period. Part of the present study was supported by the River Ecology Research Group of Japan (Chikuma River Research Group). This work was supported by Grant-in-Aid for Global COE Program by the Ministry of Education, Culture, Sports, Science, and Technology.

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