Jpn. J. Limnol., 50, 2, 157-161, 1989.

Note

Seasonal and Diurnal Changes in Emergence of *Potamanthodes kamonis* in a Stream of Central Japan (Ephemeroptera : Potamanthidae)

Naoshi C. WATANABE

Abstract

Seasonal and diurnal changes in emergence of *P. kamonis* were studied using a light trap and emergence traps in a stream of central Japan in 1978-1980. The main emergence period was from mid-July to the end of September. Most of the winged adults collected were subimagos. Subimagos gradually decreased in size during the emergence periods in 1979 and 1980, but this tendency was not so clear in 1978. The emergence continued from sunset to sunrise each day in the middle of the emergence period, but it ceased far earlier before sunrise on the early and later days of the period. The daily emergence time of females was somewhat earlier than that of males, and the proportion of males to females gradually increased toward sunrise.

Key words : mayfly, emergence, seasonal and diurnal change, protogyny

1. Introduction

Ecological information for the sprawling mayfly, *Potamanthodes kamonis* (Imanishi), is very limited, although this species is widely distributed in Japanese streams. There are some descriptions of the emerging habit (IMANISHI, 1938) and the emergence period (GOSE, 1973). WATANABE (1988) recently reported on the basis of seasonal change in nymphal size that this species has three cohorts a year which emerge one after another from June to early October. Information on other species of this family is also limited, apart from taxonomic descriptions. Except for reports on the habitat and life cycle of *Potamanthus myops* (BARTHOLOMAE and MEIER, 1977) or on its intraspecific variation in taxonomic characteristics (LORD and MEIER, 1977), there are but a few brief notes on the biology of this particular mayfly (IDE, 1935 ; LANDA, 1968 ; MCCAFFERTY, 1975).

This preliminary report provides a description of the seasonal and diurnal patterns of *Potamanthodes kamonis* emergence.

2. Materials and methods

The study area is located in the upper reaches of the Hatsukagawa Creek (35°01'N, 135°17'E, 340 m in altitude), a tributary of the Muko River in central Japan. A detailed description of the study area is found in WATANABE (1988).

Imagos and subimagos of *Potamanthodes kamonis* were collected by a light trap at the river bed just below a pool (Fig. 1). The light trap samplings were usually made weekly or biweekly from June to October in 1978-1980. A butane gas light was put in the center of a polyethylene tray (71×49 cm base and 6 cm sides) filled with about 1 cm of ethanol solution. A small black curtain was put between the light trap and the pool so that the light might not disturb the mayfly emergence from the pool. Subimagos and imagos trapped in the solution were collected every two hours from sunset to sunrise in 1979 and 1980, although all the mayflies trapped were collected after sunrise in 1978.

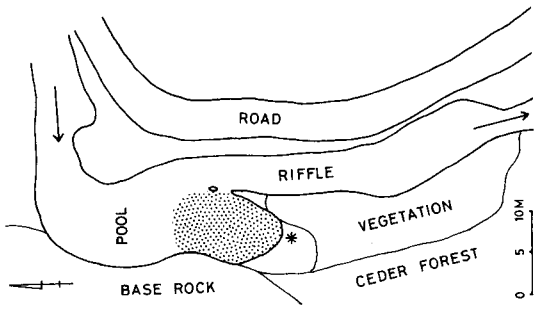

Fig. 1 Sketch map showing the survey site. The emergence traps were situated in the dotted area. The light trap was set at the point shown by an asterisk.

In addition, collections by emergence traps were made in 1979. The emergence trap was made of a cubic steel frame (60 cm on each side) and nylon net of 1 mm mesh wrapped around the frame except for the bottom. On the upper side of the trap there was a chimney-like aperture which was usually closed, but through which an insect aspirator could be inserted for sampling. Five emergence traps were arbitrarily set in the lower part of the pool and were cleared every two hours for 24 hr.

Specimens of *P. kamonis* were preserved in 50% ethanol. In the laboratory, they were sexed, counted and measured in terms of body length to the nearest 0.1 mm using a binocular microscope with an objective micrometer.

Nymphs having dark wings were collected on 30 July 1980 in the Hatsukagawa Creek and reared in the laboratory. Each of the emerging subimagos was kept in a small vessel separately under a natural light condition and uncontrolled room temperature ranging from 24.6°C to 31.4°C. The vessels were checked usually every half hour, and the length of subimaginal period was examined.

3. Results and discussion

All the winged adults of *P. kamonis* collected throughout the study period were subimagos except for a male and a female imagos obtained by the light trap in 1979, although subimagos moulted to imagos in the laboratory as will be shown later.

Table 1 shows the number of winged adults collected with the light trap and the emergence traps on each sampling day in 1978-1980. The main emergence period was from mid-July to the end of September, although a few mayflies were collected in June and October. There seems to be no significant difference in emergence period between the sexes. However, either males or females predominated the light trap samples on many days. Also in yearly total, males in 1979 and 1980, and females in 1978, respectively, predominated in the light trap samples (significant at 1% level by a χ^2-test). On the other hand, there was no significant difference in the numbers collected from the emergence traps between the sexes every day and in yearly total. Therefore, the sex ratio of emerging mayflies is likely to be around unity, but certain factors seem to affect the difference in numbers between males and females attracted to the light trap.

Figure 2 shows the daily change in size of subimagos collected with the light trap. Females were larger than males in each sample. In 1979 and 1980, the size of both males and females gradually decreased during the emergence period, although this tendency was not so clear in 1978.

It is well known that adult size gradually decreases during the emergence period in many mayflies. SWEENEY and VANNOTE (1981) attributed it to the existence of a threshold temperature below which only larval tissues exhibit differentiation and growth, and above which adult tissues of larva develop towards metamorphosis : therefore, adult size depends largely on larval size at the onset of adult tissue synthesis under an increasing temperature. The gradual decrease in adult size of *P. kamonis* could be explained with the above

Table 1. Number of *P. kamonis* collected by the light trap and the emergence traps.

	1978 Light trap				1979 Light trap				1979 Emergence trap			1980 Light trap			
	Date	♂	♀	T	Date	♂	♀	T	♂	♀	T	Date	♂	♀	T
					12	0	0	0	0	0	0	11	0	0	0
June	14	1	0	1								18	0	0	0
												25	1	0	1
												2	1	6	7
					9	7	7	14	2	1	3				
July					16	17	19	36	1	0	1	16	3	3	6
												22	9	3	12
	25	13	46	59	30	228	154	382	6	11	17				
												6	26	11	37
	10	12	52	64											
August					14	316	318	634	12	16	28				
	22	104	82	186								20	27	12	39
					29	67	29	96	16	10	26				
	6	2	8	10								2	5	7	12
September					12	64	37	101	11	13	24				
												17	19	7	26
	20	67	100	167											
	4	1	3	4								1	0	0	0
					11	1	0	1	0	0	0				
October	18	0	0	0								16	0	0	0
					24	0	0	0							
Total		200	291	491		700	564	1,264	48	51	99		91	49	140

Table 2. Diurnal change in the number of males and females (parenthesis) of *P. kamonis* collected by the emergence traps (A) and the light trap (B) in 1979.

		sunset	18	20	22	Time 0	2	4	sunrise
(A)									
9	July	19 : 15		1(1)	1(0)				4 : 54
16		19 : 13			1(0)				4 : 56
30		19 : 04	0(1)	0(4)	3(4)	1(1)	2(1)		5 : 07
14	August	18 : 50	0(2)	5(9)	2(3)	1(1)	3(1)	1(0)	5 : 18
29		18 : 31	0(2)	1(5)	7(3)	2(0)	4(0)	2(0)	5 : 29
12	September	18 : 12	7(12)	3(0)	0(1)	1(0)			5 : 39
11	October	17 : 31							6 : 00
(B)									
9	July	19 : 15		5(4)	2(3)				4 : 54
16		19 : 13		5(12)	9(5)	2(2)		1(0)	4 : 56
30		19 : 04	0(1)	23(68)	87(58)	62(21)	56(6)		5 : 07
14	August	18 : 50	4(14)	150(267)	110(31)	28(5)	17(1)	7(0)	5 : 18
29		18 : 31	0(11)	7(8)	14(5)	7(1)	21(3)	18(1)	5 : 29
12	September	18 : 12	32(35)	23(2)	8(0)	1(0)			5 : 39
11	October	17 : 31	1(0)						6 : 00

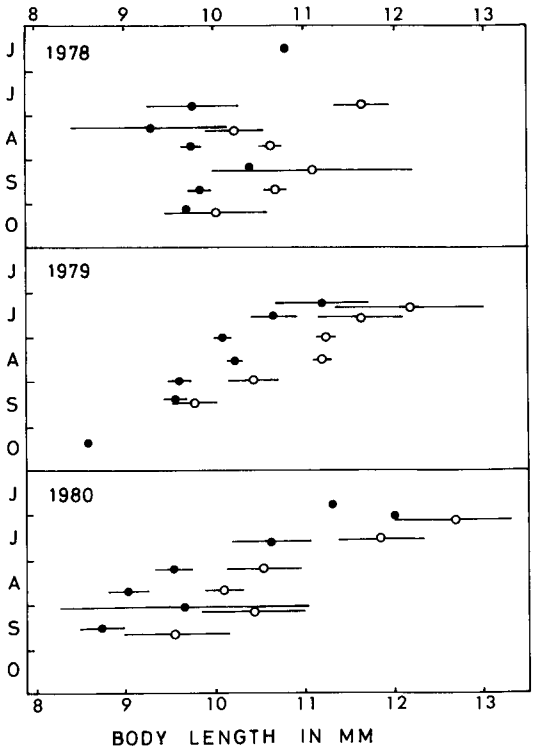

Fig. 2 Seasonal change in the body length of subimagos during the emergence period (mean and ±95% confidence limits). Solid and open circles show males and females, respectively.

hypothesis, because a cohort which had had a shorter growth period as nymphs emerged later as smaller adults (WATANABE, 1988).

Table 2 shows the number of *P. kamonis* collected every two hours from sunset to sunrise with the emergence traps and the light trap in 1979. The emergence traps were checked also during the day, but no mayflies were collected. Therefore, the emergence occurred between sunset and sunrise. In the middle of the emergence period, from 30 July to 29 August, the emergence continued from sunset to sunrise, whereas at the beginning and the end of the emergence period it did not occur before sunrise. Toward the end of this period, peak emergence tended to be earlier. These tendencies were also found in the light trap samplings. Also, the daily emergence time of females was somewhat earlier than that of males, and the proportion of males to females gradually increased toward sunrise.

The daily emergence of males and females is usually synchronous in mayflies (BOERGER and CLIFFORD, 1975 ; FRIESEN *et al.*, 1980), although in *Dolania americana* (PETERS and PETERS, 1977) and *Ephoron shigae* (N. C. WATANABE, in press) whose females oviposit as subimagos and males molt to imagos, the males emerge well before the females. A case of females emerging prior to males, like *P. kamonis*, has never been reported in mayflies. THORNHILL and ALCOCK (1983)

Table 3 The length of subimaginal period of *P. kamonis* in the laboratory.

Females			Males		
time of moulting		length of subimaginal period	time of moulting		length of subimaginal period
nymph → subimago	subimago → imago		nymph → subimago	subimago → imago	
(30 July)	(31 July)		(31 July)	(31 July)	
20 : 00	13 : 40	17hr 40min	2 : 00	17 : 00	15hr 0min
21 : 00	13 : 40	16 40	2 : 00	22 : 00	20 0
21 : 00	13 : 40	16 40	3 : 00	20 : 00	17 0
21 : 00	13 : 00	16 0	4 : 30	20 : 45	16 15
21 : 00	14 : 00	17 0			
23 : 15	15 : 30	16 15			
(31 July)					
0 : 30	14 : 00	13 30			
average length of subimaginal period*		16hr 15min			17hr 4min

* no significant difference between the sexes by a t-test

argued that protogyny, the emergence of females before males, could evolve in species in which the females mate more than once, and the male mating with a female after other males is able to displace or supplant sperm donated by earlier mates, or in which the adult pre-reproductive period of females is longer than that of males. In the laboratory, no difference was detected between the sexes in the length of the subimaginal period (Table 3). Investigations of mating behavior are necessary for further discussion.

摘　　要

キイロカワカゲロウ羽化の経日・日周変化

兵庫県羽束川において，1978年から1980年の6－10月に，ライト・トラップと羽化トラップを用いてキイロカワカゲロウを採集し，羽化の経日的・日周期的変化を調べた。羽化はおもに7月中旬から9月下旬の間に起こり，採集された個体はほとんどすべてが亜成虫であった。1979年と1980年においては，亜成虫のサイズは羽化期間中にしだいに減少したが，1978年にはこの傾向は明瞭ではなかった。羽化は日没後に行なわれ，羽化期の中期には日の出までの間，少しずつ羽化が継続するが，前・後期には日の出のずっと以前に終了する。雌の羽化時刻は雄よりも少し早く，遅い時刻ほど雄の割合が高くなる。

References

BARTHOLOMAE, G. and P. G. MEIER (1977) : Notes on the life history of *Potamanthus myops* in southeastern Michigan (Ephemeroptera : Potamanthidae). Great Lakes Ent., *10* : 227-232.

BOERGER, H. and H. F. CLIFFORD (1975) : Emergence of mayflies (Ephemeroptera) from a northern brown-water system of Alberta, Canada. Verh. Internat. Verein. Limnol., *19* : 3022-3028.

FRIESEN, M. K., J. F. FLANNAGAN and P. M. LAUFERSWEILER (1980) : Diel emergence patterns of some mayflies (Ephemeroptera) of the Roseau River (Manitoba, Canada). p. 287-296. *In* J. F. Flannagan and K. E. Marshall (eds.), *Advances in Ephemeroptera Biology*. Plenum.

GOSE, K. (1973) : Life histories of macroinvertebrates in the Yoshino River. Research on biological productivity in the Yoshino River, *4* : 8-16 (in Japanese).

IDE, F. P. (1935) : Life history notes on *Ephoron, Potamanthus, Leptophlebia* and *Blasturus* with descriptions (Ephemeroptera). Can. Entmol., *67* : 113-125.

IMANISHI, K. (1938) : Mayflies from Japanese torrents. IX. Life forms and life zones of mayfly nymphs. I. Introduction. Annotat. Zool. Japon., *17* : 23-36

LANDA, V. (1968) : Developmental cycles of central European Ephemeroptera and their interrelations. Acta Ent. Bohemoslov., *65* : 276-284.

LORD, R. J. and P. G. MEIER (1977) : Intraspecific variation in taxonomic characteristics of the mayfly *Potamanthus myops* (Walsh). Great Lakes Ent., *10* : 51-58.

MCCAFFERTY, W. P. (1975) : The burrowing mayflies of the United States (Ephemeroptera : Ephemeroidea). Trans. Amer. Ent. Soc., *101* : 447-504.

PETERS, W. L. and J. G. PETERS (1977) : Adult life and emergence of *Dolania americana* in Northwestern Florida (Ephemeroptera : Behningiidae). Int. Revue ges. Hydrobiol., *62* : 409-438.

SWEENEY, B. W. and R. L. VANNOTE (1981) : *Ephemerella* mayflies of White Clay Creek : Bioenergetic and ecological relationships among six coexisting species. Ecology, *62* : 1353-1369.

THORNHILL, R. and J. ALCOCK (1983) : *The Evolution of Insect Mating Systems*. Harvard Univ. Press.

WATANABE, N. C. (1988) : Life history of *Potamanthodes kamonis* in a stream of central Japan (Ephemeroptera : Potamanthidae). Verh. Internat. Verein. Limnol., 23 : 2118-2125.

(著者：渡辺　直，　香川大学教育学部環境科学研究室，〒760 高松市幸町1－1 ；Naoshi C. WATANABE, Environmental Science Laboratory, Faculty of Education, Kagawa University, Saiwai-cho 1-1, Takamatsu 760.)

Received : 17 October 1988
Accepted : 23 December 1988