

Life History Aspects of *Ephemera separigata* Bae (Ephemeroptera : Ephemeridae) from a Mountain Stream in Central Korea

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ABSTRACT: *Ephemera separigata*, the uppermost stream representative among Korean *Ephemera* spp., was monthly sampled from a stream of Chiak Mt. in central Korea from March to November in 1996 to examine its life history aspects. As a result, *E. separigata* was most probably considered univoltine, emerging relatively for a short period from late May to early June. Larval growth was most rapid just before the emergence (April to June). Growths of larval body parts (head width, thorax width, tusk length) were symmetrical with body length ($r > 0.94$) except for wingpad length in last instar larvae. Discussions on life history adaptations between Korean and Japanese *Ephemera* spp. were provided.

Key words : Life history, *Ephemera separigata*, mayfly, Korea

INTRODUCTION

Ephemera separigata, an endemic ephemerid mayfly to Korea, was recently described by Bae (1995). Its distribution was also known from North Korea (Bae and Soldán, unpublished). Larvae and adults of *E. separigata* are most similar to those of *E. strigata*, but they can be easily distinguished from other *Ephemera* spp. by their narrow and greatly departed paired stripes on the abdominal segment 7-9 (see Fig. 1 in Bae, 1995).

Larvae of *E. separigata* have been paid attention to us because of their altitudinal distribution with other *Ephemera* spp., *E. strigata* and *E. orientalis*, in Korea. When they occur in the same stream water course, they showed a distinct altitudinal distribution; and demarcations in this altitudinal distribution were clear. *Ephemera separigata* always inhabited in the uppermost section of the stream, followed by *E. strigata* and *E. orientalis* (Bae, 1995; Lee *et al.*, 1995). This

interesting distributional patterns have been known in Japanese *Ephemera* spp. (Kuroda *et al.*, 1984; Watanabe, 1985), European *Ephemera* spp. (Soldán, pers. comm.), and North American *Ephemera* spp. (McCafferty, 1975).

The purpose of this study is to understand life history aspects of *E. separigata* associated with its spatial and temporal adaptations.

MATERIALS AND METHODS

Larvae of *E. separigata* were monthly sampled from a mountain stream in the Sangwonsa valley of the Chiak Mt. in central Korea from March to November in 1996. The Sangwonsa valley is located in the southern slope of the Chiak Mt., which is a part of the Chiak Mt. National Park. Upper reaches of the stream have been well preserved, while mid and lower reaches of the stream have recently been much affected by human activities.

Our pilot study indicated that *E. separigata* occurred in the uppermost section of the stream (altitude 500-850 m), belonging to the first thro-

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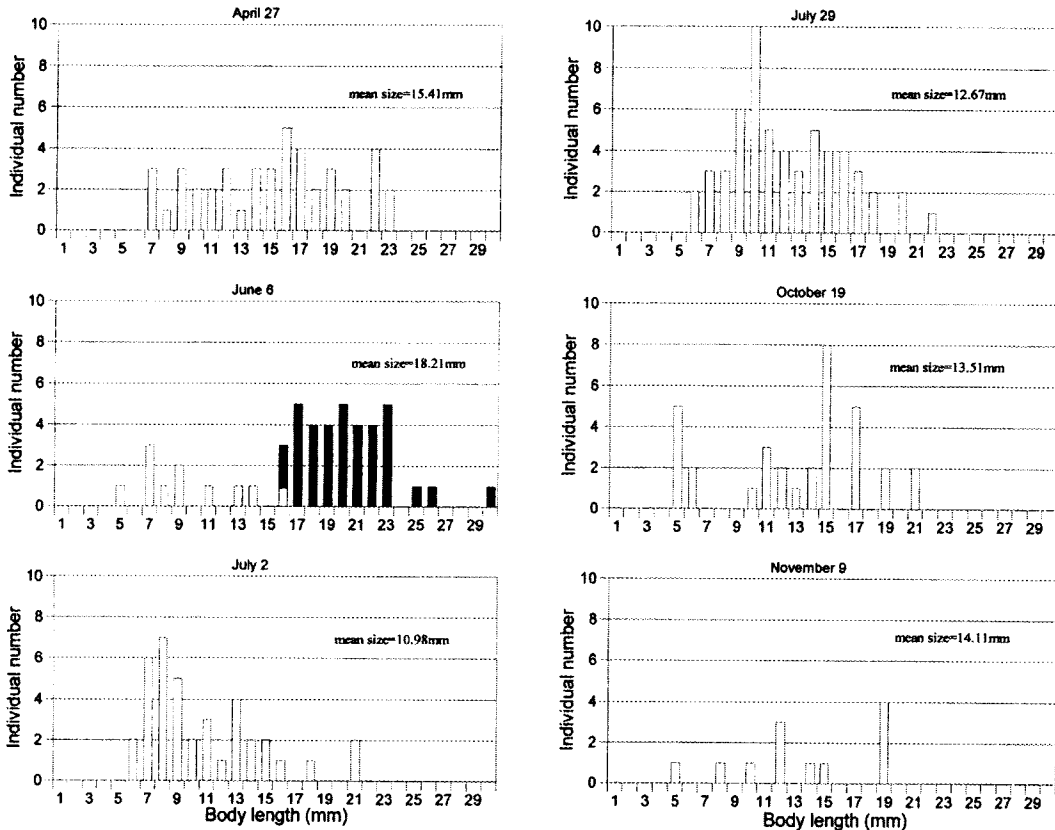


Fig. 1. Body size frequency distribution of *E. separigata* from a stream of Chiak Mt. in central Korea in 1996. Black bars indicate last instar larvae with dark wingpads.

ugh third order stream. We thus selected several sites at the altitudinal range between 500 m and 850 m for samplings. We, however, used samples collected at the sites between 550 m and 600 m for this study because *E. separigata* was most abundant in the area and temperature differences between sampling sites were considered. Our previous study (Lee *et al.*, 1995) indicated that temperature was a major determinant in the distribution of *E. strigata* and *E. orientalis*.

Samplings were taken monthly (April 27, June 6, July 2, July 29, October 19, and November 9) in 1996 using a scoop net (diameter 20 cm; mesh size 0.5 mm). About 40~50 larvae were taken at each sampling except in November when the larvae were scarce.

Body length, head width, tusk length, and wingpad length were measured by a micrometer on a dissect microscope. Emergence was estimat-

ed by counting last instar larvae as well as the appearance of the alate stages.

RESULTS

The body size frequency distributions at each sampling month are shown in Fig. 1. Diverse sized larvae were relatively evenly distributed in late April, but last instar larvae were predominant (76.6%) in early June. In early July, after a month, most small sized larvae were recruited (mean body size 10.98 mm), but fully grown larvae were not found. In late July, midgrown larvae were predominant (mean body size 12.67 mm) and the size frequency showed almost a normal distribution. In October and November, although larvae were not sampled enough, mean body size gradually increased (13.51 mm and 14.11 mm, re-

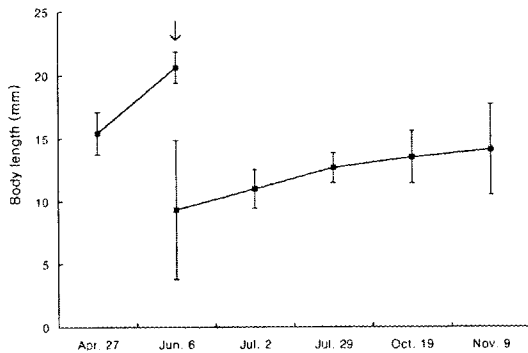


Fig. 2. Standard deviation and mean body length showing larval growth of *E. separigata* from a stream of Chiak Mt. in central Korea in 1996. Arrow indicates emergence timing.

spectively).

Fig. 2 indicates the range of one standard deviation and mean of the larval body length at each sampling month. In early June, two distinct size groups, early to mid-grown larvae (mean 9.32 mm) and fully grown and last instar larvae (mean 20.61 mm) were discriminated, which may indicate that emergence takes place around the sampling date (late May to early June). It also indicates that the larval growth was much rapid just before the emergence, while it was slow and gradual all through the seasons after emergence.

Growths of larval body parts, i.e. head width ($r=0.9488$), thorax width ($r=0.9487$), and tusk length ($r=0.9531$), were symmetrical with body length (mean $r>0.94$) except for forewingpad length ($r=0.6493$) in last instar larvae.

Based on our observations, last instar larvae have not been found after June and any discrete cohorts have not been found since then. This may indicate that *E. separigata* has a univoltine life cycle emerging relatively for short period from late May to early June.

DISCUSSION

Ephemera separigata resembles Japanese *E. japonica* with respect to their habitat adaptation because both of the species are the uppermost stream representatives of *Ephemera* in their country (Kuroda et al., 1984; Watanabe, 1985; Lee et al., 1995). (Previous some distributional re-

cords of *E. japonica* in Korea are most probably erroneous.) This may assume that they are cold-adapted and their life history adaptations may be related to each other.

Duration and timing of the emergence between *E. separigata* and *E. japonica*, however, look different in some aspects. Emergence duration of *E. separigata* is somewhat shorter (late May to early June), while that of *E. japonica* is relatively longer covering May through September (Kuroda et al., 1984). Although majority of mayflies represent univoltine winter cycle, ephemerids, i.e. *Ephemera* and *Hexagenia*, are the major semivoltine group (Clifford, 1982). Our data indicate that relatively short emergence period of *E. separigata* may fully support its univoltine life cycle. On the other hand, it is not clear that *E. japonica* is either univoltine or semivoltine (Kuroda et al., 1984).

In fact, widespread emergence duration is in common in lowland or warm-adapted mayflies as in *Potamanthodes* (Watanabe, 1988) and *Anthopotamus* (McCafferty and Bae, 1994) in other ephemeroids, and much complicated life history aspects are found among them. Our casual observations indicate that *E. orientalis*, the downstream representative among Korean *Ephemera* spp., may have more complicated life history pattern because *E. orientalis* shows widespread emergence pattern possessing more than two distinct cohorts as in Japanese *E. orientalis* (Watanabe, 1992).

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국문적요 : 강원도 치악산 계류에 서식하는 가는무늬하루살이의 생활환. 이성진·배연재·윤일병 (고려대학교 생물학과, 서울여자대학교 생물학과) 한국에 서식하는 하루살이류 중 산간계류의 대표적인 종으로 알려진 가는무늬하루살이의 생활환을 밝히기 위하여 강원도 치악산 상원사 계곡 계류에서 1996년 3월부터 11월까지 월 1회 정성채집을 수행하였다. 가는무늬하루살이는 1년 1세대의 전형적인 생활환을 나타내었으며, 우화기간은 5월 하순에서 6월 중순으로 비교적 짧은 것으로 나타났다. 유충의 성장은 우화직전에 가장 증가하였으며, 시초를 제외한 전흉폭, 두폭, tusk의 길이 등은 체장과 높은 상관관계를 나타내었다 ($r > 0.94$). 가는무늬하루살이의 생활사 특성은 이들과 유사한 서식처를 점유하는 일본산 하루살이, *E. japonica*와 다소 차이를 나타내었다.

검색어 : 생활사, *Ephemera separigata*, 하루살이, 한국