PARTHENOGENESIS IN SOME HONG KONG MAYFLIES (EPHEMEROPTERA)

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INTRODUCTION

Parthenogenesis in mayflies has been described in several species of Baetidae, Leptophlebiidae, Caenidae, Ephemerellidae, Polymitarcyidae and Heptageniidae (Humpesch, 1980; Sweeney & Vannote, 1987; Gillies & Knowles, 1990; Harker, 1997; Watanabe & Ishiwata, 1997). Two reproductive strategies involving egg development without fertilization may occur: normal parthenogenesis (which may be obligatory or facultative), and accidental parthenogenesis. Accidental parthenogenesis (tychoparthenogenesis) can occur in populations where males are present (i.e. in normally sexually reproducing species), while obligatory parthenogenesis has been found in species where males are rare or appear to be lacking entirely (Bergman & Hilsenhoff, 1978; Gibbs, 1977). Facultative parthenogenesis, where eggs can hatch with or without fertilization, seems widespread among mayflies (Sweeney and Vannote, 1987), however the ecological importance of parthenogenetic populations and the success of such individuals in the field have received little attention (see Sweeney & Vannote, 1987; Harker, 1997; Watanabe & Ishiwata, 1997). There is little information on parthenogenesis in Asian mayflies (Watanabe & Ishiwata, 1997) and the present study documents its occurrence in four species - three baetids and a leptophlebiid.

METHODS

Larvae of *Choroterpes* sp., *Procloeon* sp., *Chopralla* sp., *Centroptilum* sp., *Cinygmina* sp. and *Electrogena* sp. were collected from a forest stream located inside Shing Mun Country Park, New Territories, Hong Kong SAR (lat. 22°09'N), during May 1996. Species were reared separately in plastic tanks containing abundant food in the form of periphyton on stones collected from the field. Female preimagines emerging from the tanks were immediately transferred to individual plastic vials containing sterile stream water (autoclaved at 121°C for 30 minutes). Unmated adult females of *Choroterpes* sp., *Procloeon* sp., *Chopralla* sp. and *Centroptilum* sp. that emerged in the laboratory laid their eggs spontaneously after completing the last molt to the imaginal stage. Eggs from *Cinygmina* sp. and *Electrogena* sp. were obtained by dissecting adult females. Eggs from each female were transferred to single sterile petri dish, containing 15 ml of sterile stream water, and the dishes were kept at room temperature (22 ± 2°C). Eggs were checked daily under a stereomicroscope, and any emerged larvae were counted and removed from the petri dishes. The sterile stream water was renewed every two to three days. The eggs were regularly monitored until five days after hatching had stopped. Observations were discontinued after five days because most eggs became covered by fungi.

RESULTS

It took from 7.5 to 12 days until the first mayfly egg from any batch hatched in the laboratory at ≈ 22°C (Table 1). Time to first hatching was similar for the three baetids (7.5-9.0 days), and was 12 days for *Choroterpes* sp. Eggs from *Cinygmina* sp. and *Electrogena* sp. did not hatch in the laboratory. Eggs of *Procloeon* sp. and *Chopralla* sp. had similar hatching success (73 and 71%,respectively), while 41% of *Centroptilum* sp. eggs hatched, but only 13% of *Choroterpes* sp. eggs. Mean hatching times for the entire egg batch ranged from 11.6 to 14.6 days according to species (Table 1). Emergence of first-instar larvae continued for at least 14 days in all species, which is indicative of asynchronous hatching. Most eggs of *Procloeon* sp. (70%) had hatched within 15 days of oviposition, and hatching declined steeply thereafter until day 21 (Fig. 1). *Chopralla* sp. eggs showed a maximum hatch between days 9 to 13 (Fig. 1), then declined steadily until day 19 when hatching ceased. *Centroptilum* sp. eggs hatched continuously over a 22-day period beginning on day 6; hatching ceased on day 28 (Fig. 1). The highest number of *Choroterpes* sp. eggs hatched between days 11 and 14, although hatching continued until day 25 (Fig. 1).

Table 1. Egg development time of mayflies under laboratory conditions. Eggs were collected from females that emerged in the laboratory, and were kept in petri dishes at 22 ± 2°C. Data represent mean values ± SE.

Species	First eggs hatched (days)	*n*	Number of eggs (range)	Hatching time (days)	Hatching success (%)
Chopralla sp.	8.8 ± 1.4	4	413 (103-976)	11.6 ± 1.1	71 ± 8.8
Procloeon sp.	9.0	1	1547	13.2	73
Centroptilum sp.	7.5 ± 0.9	4	941 (204-1360)	13.7 ± 0.9	41 ± 6.5
Choroterpes sp.	12 ± 0.6	3	663 (637-703)	14.6 ± 0.8	13 ± 5.3

DISCUSSION

Adult females of *Chopralla* sp., *Centroptilum* sp., *Choroterpes* sp. and *Procloeon* sp. that had emerged in the laboratory laid their eggs spontaneously without fertilization, and yet achieved hatching successes of 13 to 73%. Temperate baetids may show slightly faster egg development: e.g. *Baetis rhodani* eggs hatch in 9 days at 20°C (Elliott, 1972), hatching in *Cloeon triangulifer* takes 11 days at 25°C (Sweeney & Vannote, 1984). Nevertheless, values from 8-32 days have been reported for several parthenogenetic *Baetis* spp. at temperatures ranging from 19 to 23°C (Bergman & Hilsenhoff, 1977), and the Hong Kong results are quite similar to these findings. *Choroterpes* sp. eggs began to hatch 12 days after oviposition, with a mean hatching time of 14 days. Similar results have been observed for unfertilized eggs of *Thraulodes* sp. from a Costa Rican stream, where hatching began 18 days after oviposition at 20°C, with a median hatching time of 19 days (Jackson & Sweeney, 1995).

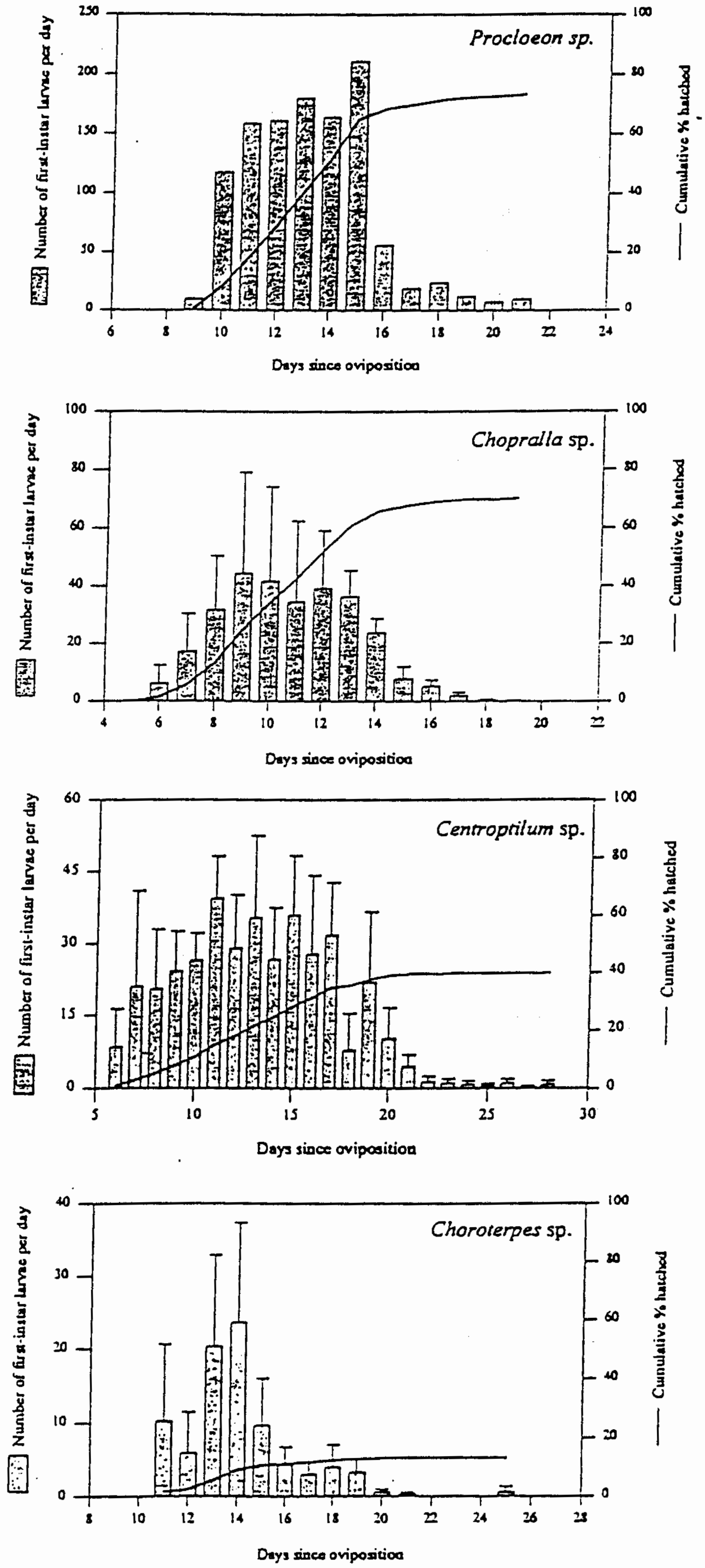

Figure 1. Hatching of mayflies eggs in the laboratory. Unfertilized eggs of: *Procloeon* sp. (n = 1); *Chopralla* sp. (n = 4); *Centroptilum* sp. (n = 4); and, *Choroterpes* sp. (n = 3), were kept separately at room temperature and the hatched larvae recorded daily. Bars represent mean values with standard errors.

In this study, *Procloeon* sp., *Chopralla* sp. and *Centroptilum* sp. showed normal parthenogenesis, while *Choroterpes* sp. - with only 13% of unfertilized eggs hatching - may have exhibited accidental parthenogenesis. Because males of *Chopralla* sp. *Centroptilum* sp. and *Procloeon* sp. are present in Hong Kong populations, it seems that these mayflies exhibit facultative parthenogenesis.

The advantage of parthenogenetic development is that it may ensure the continuation of a generation in the event that a mate cannot be found (Templeton, 1982). Most mayflies in Hong Kong streams, as in most tropical areas, exhibit asynchronous development and continuous adult emergence without swarming (Edmunds & Edmunds, 1979; Dudgeon, 1995; Dudgeon, 1996). This may reduce the chances of finding a mate (relative to species that swarm in temperate regions), but minimizes the risks of predation (Edmunds and Edmunds, 1980). Under such conditions, facultative parthenogenesis may be adaptive. Similarly, if mayfly populations decrease drastically, as can occur following spates during the wet season, parthenogenesis might be advantageous. It is tempting to speculate that parthenogenicity - especially facultative parthenogenicity - might be advantageous in environments which are regularly disturbed, where abiotic factors rather than biotic factors influence population size.

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