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A simple, inexpensive artificial stream for rearing Ephemeroptera from sandy substrates

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Abstract

We describe a simple, inexpensive artificial stream to rear mayflies from sandy bottom streams. It consisted of a 151 L tub containing sand and water from a local stream. A small submersible pump circulated the water and netting was placed over the tub to collect adults. The stream was operated in a heated greenhouse. This artificial stream was remarkably productive. We collected over 2100 adult mayflies representing 6 genera along with several Trichoptera and Diptera adults. This stream was productive for 55 weeks with minimal maintenance.

Key words: mayflies, nymphs, adults, parthenogenesis

Introduction

Artificial streams have been used to study a number of aspects of aquatic invertebrate biology including energetics, productivity, behavior, disturbance, ecotoxicology, and community structure (Lamberti & Steinman 1993). In addition such streams are useful to maintain a stock of study organisms (Fremling 1967) and rear immatures to the adult stage for identification (Mason & Lewis 1970).

We have been studying the ecology and feeding preference of *Cercobrachys winnebago* Sun & McCafferty (Ephemeroptera: Caenidae) and needed an effective and simple means to rear and observe this sand-dwelling species. There are many designs for artificial streams (e.g., see Lamberti & Steinman 1993), but most are quite complex and expensive and more suitable for holding rocky substrates.

In this paper, we describe a simple artificial stream that we originally designed to rear *C. winnebago*. However, once this artificial stream was operational, we could no longer find *C. winnebago* in our study stream. This was likely due to an extensive drought which reduced stream volume and contributed to extensive algal growth on the habitat of this species. Nevertheless, our design was successful for rearing other genera of sand-dwelling mayflies from the study stream, and so we herein report on that success.

Material and methods

The artificial stream

The artificial stream (Figs. 1 and 2) was constructed using a 151 L oval plastic tub (69 cm wide x 97 cm long x 33 cm high; KMT 101, Tuff Stuff Products, www.tufftubs.com) equipped with a 454 L/h submersible pump (EasyPro EP 120, easypropondproducts.com) to circulate the water. The pump was placed on top of a plastic test tube rack to raise it above the substrate and prevent fouling from the moving sand. The pump released water 6 cm above the sand and parallel to the minor axis of the oval tub.

This stream was operated in a heated greenhouse. It required approximately 1.1 m^2 of space.

Substrate, water and specimens were collected from Little Deep Creek, a sandy bottom stream east of Weatherford, Oklahoma, USA. In the creek, we removed the top several centimeters of sand from the

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microhabitat of *C. winnebago*. This sand was washed through two sieves (US ASTM #5 – 4.00 mm and #8 – 2.36 mm) into a bucket to remove large debris, molluscs and predators. Stream water was added to the bucket and the sand was agitated to suspend the finer particles which were poured off. This washing was repeated several times.

FIGURE 1. Overhead view of artificial stream. Pump is in the tub on the bottom of the photo (connected to electrical cord). Two large, dark stones rest on the sandy substrate. A maximum-minimum thermometer is to the right.

This washed sand was placed in the tub to a depth of approximately 4 cm along with 60 L of stream water (water depth = 15 cm). Fine mesh netting covered the tub to aid in collecting adults (Fig. 2). Adults were collected several times each week.

Water lost from evaporation was replaced periodically with deionized water. Approximately 20-48 L of tub water was replaced with stream water every 3-17 weeks (5 times during the study), and approximately 4 L of sand was added every 5-17 weeks (4 times during the study). During the 16th week of the study 2 large rocks were added to the tub and during the 44th week approximately one-half of the sand was replaced.

Results and discussion

Production of adults

The artificial stream was maintained for 55 weeks, from August 2013 through September 2014. Adults were first collected from the tub less than three weeks after the artificial stream was operational and it continually produced adults throughout the study.

Over 2100 adult mayflies were collected from the artificial stream representing six genera: *Apobaetis*, *Baetis*, *Callibaetis*, *Fallceon* and *Pseudocentroptiloides* (Baetidae) and *Tricorythodes* (Leptohyphidae). No

adults of *C. winnebago* were collected. In addition adults of Leptoceridae (Trichoptera) and Chironomidae (Diptera) were also collected.

FIGURE 2. Artificial stream with netting to aid in collecting emerging adults. This setup required only 1.1 m^2 of space.

Rearing conditions

These mayflies were successfully reared with minimal care. This artificial stream was placed in a greenhouse environment in which the air temperature varied from 8 to 35 ºC and the water temperature varied from 13 to 34 ºC. Yet, given these conditions, adult mayflies were collected throughout most of the 55 week study.

Even though this tub was relatively small (approximately 0.47 m^2), variation in flow velocity produced several microhabitats consisting of different combinations of fine, medium and course sand.

Source of specimens

During the times we visited Little Deep Creek to obtain water and sand for the artificial stream, we also collected live nymphs which were added to the tub. Over the course of this study, fewer than 50 live nymphs were added to the artificial stream. These added specimens accounted for only a small percentage of the adults produced. Some of these adults probably developed from eggs and nymphs that were in the collected sand. However, sand was collected only four times during the 55 week study.

We observed that the sex ratio of adults was 1 male to 3.8 females so parthenogenesis was the most likely source of specimens. Funk *et al*. (2010) concluded that parthenogenesis is common in mayflies. Also,

gynandromorphs were not uncommon among our specimens and these can result from facultative parthenogenesis (Funk *et al.* 2010).

Regardless of the source of specimens, the results indicated that conditions in the artificial stream were favorable for the development of eggs and nymphs.

Conclusion

This small, simple, artificial stream design allowed us to successfully raise many sand-dwelling mayflies to the adult stage with limited effort and cost.

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