A LABORATORY FLOW TANK WITH VARIABLE CURRENT AND DEPTHS FOR REPLICATING RIFFLES AND SHALLOW STREAMS

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ABSTRACT.—Laboratory streams have been used for ecological studies of lotic organisms, providing a means to determine the relative importances of physical factors in structuring communities. Herein, an inexpensive (less than $500) artificial stream is described that has several advantages over other designs. It offers: 1) accurate current velocities of 0 to 45.5 centimeters per second; 2) a large surface area for experimentation; 3) both spatial and temporal current homogeneity; and 4) riffle simulation. This artificial stream requires approximately 1.8 square meters of floor space and can be used indoors. *Key words*: laboratory stream; flow tank; design; construction.

Studying the behavior of benthic animals is aided by laboratory studies (Cummins, 1962). For example, the association between behavior and abiotic factors can be determined by individually varying factors that are not independent in natural situations. Such experiments are fundamental to studies of interspecific interaction (competition or predation) or habitat selection.

Artificial streams provide a means to experimentally modify a number of parameters that are correlated in nature or would require extensive modification of natural systems. The options in artificial stream design include open or closed systems (Gee and Bartnik, 1969). Open systems require constant flow of new water and are useful in observing the spawning behavior of fish (Gee and Bartnik, 1969); however, it is difficult to suppress environmental influences and this design includes many natural constraints. The closed system, in which water is internally circulated, is often used in aquatic insect studies and can be used to determine which factors affect behavior and distribution of macrobenthos. Closed systems have been used to rear insect larvae (Sudia, 1951; Mason and Lewis, 1970), determine the effects of siltation on the microdistributions of stream insects (Cummins and Lauff, 1969), evaluate the effects of substratum type on prey vulnerability (Fuller and Rand, 1990), and determine the effects of population density on the emigration rates of aquatic larvae (Wiley, 1981).

Proper simulation in closed systems requires an appropriate pump mechanism. For example, air-powered (Mackay, 1981) and propellor-powered designs (Hartman, 1965; Vogel and LaBarbera, 1978) have been used; however, spatially uniform currents were difficult to obtain.

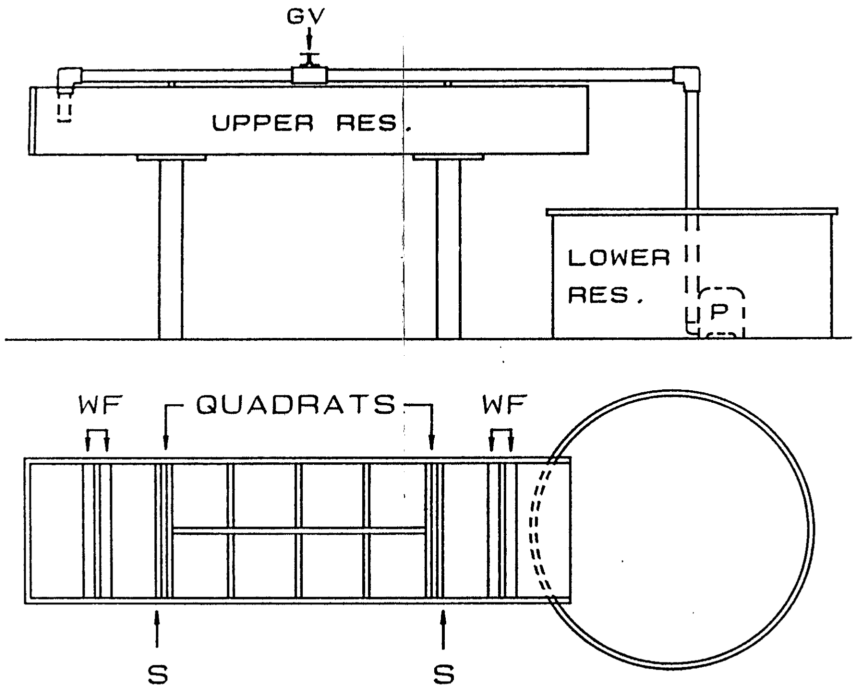
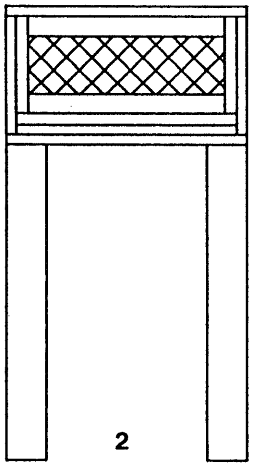


FIGURE 1. Upper. Side view depicting overall format of the artificial stream. Water is cycled through the pump within the lower reservoir into the upper reservoir. Lower. Plan view showing components (quadrats, weir, and screen frames) within the upper reservoir. Abbreviations are: GV, gate valve; WF, weir frame; S, screen; P, pump.

Techniques can be used to minimize heterogeneous currents and turbulence. Lauff and Cummins (1964) developed an excellent design that produced uniform currents; however, velocities apparently were limited (see Cummins and Lauff, 1969). Thus, design problems are two-fold: either spatial uniformity is not achieved, or the potential for a realistic range of current velocities is compromised by the design.

In contrast, a water-fall system provides a swift, homogeneous current in which water travels along an upper tank, falls into a reservoir, and is recycled into the upper tank. There has been reluctance to use water-fall systems because the pumps required for such designs generally heat the water and produce appreciable turbulence (Vogel and LaBarbera, 1978). The water-heating problem can be minimized by modifying the design to function as a radiator. This is accomplished by exposing the water within the upper reservoir to a large surface area, in turn, allowing for the loss of excessive heat. Turbulence can be minimized by the addition of a weir located near the site of water introduction in the upper tank.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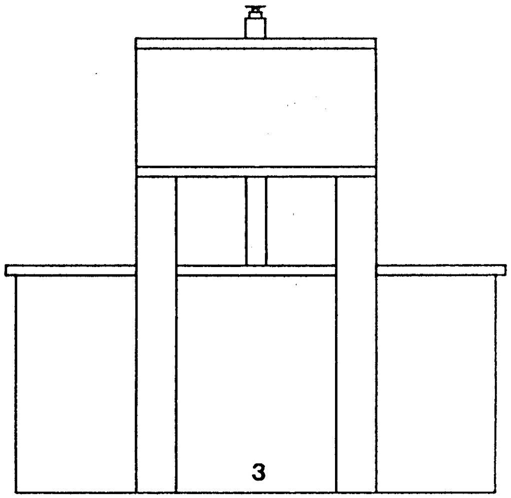
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FIGURE 2. View of lower end of upper reservoir showing weir used to raise the water level and screen for retaining organisms in the upper reservoir.

FIGURE 3. View of the upper end of upper reservoir. The site of water introduction into the upper reservoir is closed at the upstream position, thereby forcing water to travel over the experimental area toward the lower reservoir where the water is recycled.

MATERIALS AND METHODS

The artificial stream comprises three main components: 1) a rectangular plywood trough (upper reservoir) supported by four wooden posts; 2) a cylindrical galvanized tin tank (lower reservoir); and 3) a submersible sewage pump with plumbing. Water is lifted from the lower reservoir to the upstream end of the upper reservoir, where it then empties and travels through the upper reservoir. The water then falls into the lower reservoir and is recycled. Current velocities are manipulated with a gate valve and stream depths with a lower weir.

Upper reservoir.—The upper reservoir (243.8 × 60.1 × 30.5 centimeters) was constructed from 1.9 centimeters (three-fourths inch) plywood (Fig. 1). Galvanized nails and wood glue were used to secure the sides of the upper reservoir to its base. Silicon putty prevented leakage from joints and nail holes. The entire upper reservoir was coated with a potable epoxy. Fiberglass may be substituted for the epoxy. If a potable epoxy is used, the upper reservoir might require a grade-4 plastic lining to prevent possible leakage. The upper reservoir stream path was divided into eight quadrats (30.5 × 30.5 centimeters) with 2.5 centimeters (one inch) corner molding used as a partition (Fig. 1). Two 61.0 × 30.5 centimenters fiberglass screens (one square millimeter mesh) were used to retain organisms within the quadrats, collect debris, and prevent experimental materials from entering the lower reservoir (Fig. 2). Screens were located 30.5 centimeters from each end of the upper reservoir, and were attached vertically to frames constructed from 2.5 centimeters corner molding (Fig. 1) to provide stabilizaton.

Water level manipulations and the production of homogeneous currents were accomplished by the addition of two weirs. The upstream weir was located 29 centimeters from the farthest upstream position, and the second was located immediately downstream from the downstream screen frame. The weir at the upper end (61.0 × 1.9 × 10.2

centimeters) reduced turbulence caused by the introduction of water at the upstream position; whereas, the second weir (61.0 × 1.9 × 5.1 centimeters) controlled water depth. Variation in current depth was controlled by using lower weirs of different heights. Weirs were stabilized by two wooden frames (60.1 × 5.1 × 2.5 centimeters) postitioned 2.5 centimeters apart. Wooden posts (Fig. 3) (10.2 × 10.2 × 75.0 centimeters) attached beneath the upper reservoir provided support. The slope of the stream path could be manipulated by changing the heights of these supports.

Lower reservoir.—The lower reservoir consisted of a galvanized tin tank (119.4 centimeters in diameter and 61.0 centimeters in height) with a volume capacity of 2.73 square meters. This reservoir was the ideal size for the pump described herein; however, more powerful pumps may be used to increase the current velocity, and in such cases the lower reservoir size should change correspondingly.

A 0.5 Hp submersible sewage pump (Goulds, model, 3887, Seneca Falls, New York) was positioned within the lower reservoir (Fig. 1). A PVC pipe, 5.1 centimeters (two inches) in diameter, including two elbow fittings (Fig. 1), carried water from the pump to the upstream position of the upper reservoir. A brass gate valve was inserted along the horizontal length of the pipe, and regulated current velocity. All pipe joints were sealed with PVC pipe cement.

Performance.—To obtain accurate current velocities, the lower reservoir was placed behind the upper reservoir (opposite the normal position), filled with water, and depth recorded. Water was then pumped into the upper reservoir until the water level in the lower reservoir fell immediately below the intake level of the pump. Depth was measured (while the pump was running) in the upper reservoir at the position in the stream path for which a known current velocity was required. The current velocity was then calculated as $V = \pi r^2 \Delta h/ta$, where V = current velocity, r = radius of the lower reservoir, Δh = change in the water depth of the lower reservoir, t = time the pump was on, and a = cross-sectional area of the current. After six trials this system produced an average maximum velocity (± SD) of 45.45 ± 2.73 centimeters per second. With a 5.1 centimeter lower weir, an average maximum (± SD) of 13.7 ± 0.5 centimeter per second current velocity was obtained. This velocity then could be further reduced to zero without harm to the pump by closing the gate valve.

DISCUSSION

This system is inexpensive ($460.00 in 1990) and can be constructed by one person in two days. The system can be used indoors or outdoors, but indoor usage minimizes temperature fluctuations. Water temperature should be monitored with a maximum-minimum thermometer. The average water temperature after 32 hours of continuous use was 29.1°C (constant room temperature of 25°C). The 4.1°C temperature difference is attributable to electrical resistance within the pump. This temperature may not be suitable for some research; however, cooling devices are available and can be placed in the lower reservoir. Minimal temperature elevation is obtained by maintaining the lower reservoir at maximum capacity.

For studies in toxicology or those in which sensitive stream organisms are used, it is important that the upper reservoir be coated with a nontoxic (for example, fiberglass) substance to prevent intoxication of the biota. In addition, experiments should be designed that simulate depths and current velocities that correspond to the natural conditions encountered by the study organism(s). Because current velocity is inversely proportional to stream depth, relatively high lower weirs decrease the potential for swift currents (Fig. 4).

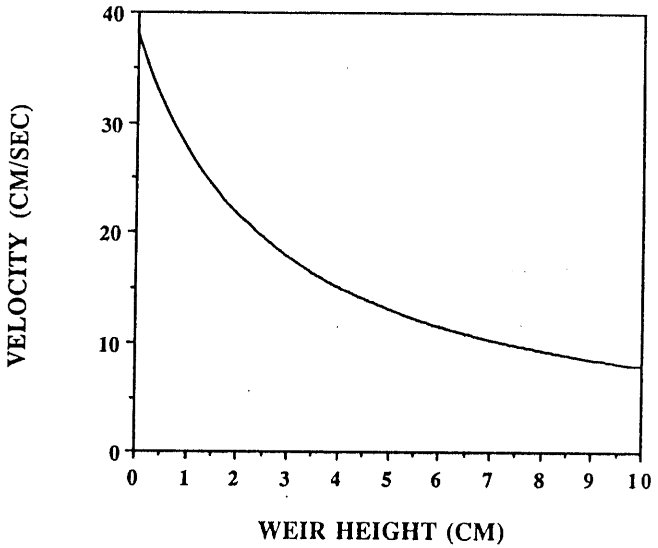

FIGURE 4. The relationship between the lower weir height and current velocity. Relatively deep streams compromise swift currents.

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NEW HOST RECORDS FOR *EIMERIA GEOMYDIS* SKIDMORE, 1929, FROM *GEOMYS* (RODENTIA: GEOMYIDAE) AND REDESCRIPTION OF THE OOCYSTS FROM *GEOMYS BURSARIUS*

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ABSTRACT.—Oocysts of *Eimeria geomydis* Skidmore, 1929, are redescribed from the type host, *Geomys bursarius*, and additional morphologic features noted. Oocysts were spherical or subspherical, 12.5 × 11.9 (11.2-14.4 × 10.4-13.6) µm [mean (range)], with a bilayered wall. Micropyle, oocyst residuum, and polar granule absent. Sporocysts were ovoidal, 7.7 × 4.9 (7.0-8.8 × 4.4-5.4) µm, with small Stieda body and containing two sporozoites and a small sporocyst residuum. In addition to *G. bursarius* from Missouri and Illinois, oocysts of *E. geomydis* also were found in the new hosts *G. breviceps* from Texas and *G. texensis* from Texas. *Key words*: *Geomys; Eimeria geomydis*; coccidia; pocket gopher.

The plains pocket gopher, *Geomys bursarius*, is a medium-sized, stocky, short-legged rodent that ranges from southern Manitoba southward through the central plains to southern Texas (Hall, 1981). Pocket gophers are adapted for a fossorial existence, spending most of their life in a subterranean burrow system. This life style suggests that these rodents may be excellent potential candidates for coccidia. Indeed, Skidmore (1929) originally described a coccidian, *Eimeria geomydis*, from a single *G. bursarius* from Lincoln, Nebraska. However, we are aware of no other records reporting coccidia since that time from any other species of *Geomys*. Herein we report on the prevalence of *E. geomydis* in *G. bursarius*, provide additional features of the coccidian not reported previously, and add two new host records for the parasite.

MATERIALS AND METHODS

Gophers were trapped between November 1990 and February 1991 and killed at capture with Macabee® gopher traps. Intestinal contents were removed from each animal and placed in Petri dishes containing a shallow layer of 2.5 percent (w/v) aqueous $K_2Cr_2O_7$ solution. Oocysts were allowed to develop for one week at room temperature (about 23°C). Oocysts then were concentrated by flotation in an aqueous sucrose solution (specific gravity 1.30), and examined and measured using Nomarski interference-contrast optics and a calibrated ocular micrometer. Ten oocysts were measured from each of three animals, the results pooled, and measurements reported in micrometers as means, followed by the ranges in parentheses.