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A Lightweight, Constant-Flow Device for Dispensing Liquid Piscicides into Streams in Remote Areas

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Abstract.—Application of piscicide is a commonly used method to remove nonnative fishes from streams for restoration of native fishes. In remote or inaccessible areas, transport facilities are limited and equipment must be portable and durable. We used 5-gal plastic buckets with sealable lids and readily available commercial hardware to construct a constant-flow device modeled on the Mariotte bottle. The device dispenses a selected steady flow of liquid piscicide over a 1–4-h period. It is economical, easily transported, and simple to construct.

Restoration of native fish to streams often requires the application of liquid piscicides to remove nonnative fishes (Rinne et al. 1981; Gresswell 1991; Stefferud et al. 1992). Type of piscicide and desired concentration may vary among projects, but a common objective is to maintain a predetermined concentration of the piscicide in the stream for a selected period of time (Rinne and Turner 1991). Dispensing the piscicide at a constant rate is necessary to ensure that the proper dosage needed to affect the target species is uniform over time and distance, and that harm to nontarget organisms is minimized or avoided. Often, target streams are in remote areas where vehicular transport of equipment is limited. Situations that require transport by horses and mules or by foot (e.g., wilderness or roadless areas) mean that equipment should be lightweight and portable. Constraints on use of piscicides in wilderness areas, concerns about dispersal downstream of treatment reaches, and scrutiny by the public encourages development of equipment that will precisely dispense piscicides, and thus diminish the margin of error inherent in field conditions. Herein we describe a device that will dispense a liquid at a constant rate over a several-hour period, is lightweight, easily transportable, and economical.

In field applications, liquid piscicide is dispensed from a "drip station" at a rate calculated to provide the desired concentration in the stream. The user determines the desired concentration, considering stream discharge and water velocity, chemistry, and temperature (Price and Haus 1963; Stefferud et al. 1992). Movement of water in the stream mixes the piscicide; however, distance traveled before uniform mixing is achieved varies depending on stream current (laminar versus turbulent flows). Several previously described designs for toxicant dispensers (drip stations) were heavy, bulky, or did not provide steady discharge (Price and Haus 1963; Rinne et al. 1981; Gresswell 1991).

Drip stations are typically containers with a drain or valve near the bottom, and discharge depends on the height of the liquid (head) above the drain. As the head decreases, so does flow rate and the piscicide is thereby dispensed at an ever decreasing rate, thus reducing its concentration in the receiving stream water. Rinne et al. (1981) used 1- and 5-gal cans to dispense piscicide over 1- and 3-h periods, respectively. Discharge from their devices was controlled by the diameter of a hole drilled near the base of the cans, and flow rate depended on the head. A valve inserted at the outlet partially stabilized discharge, but frequent adjustment was still required. Gresswell (1991) controlled discharge from 2.6- and 5.2-gal carboys with an adjustable metal clamp on plastic tubing extending from the outlet nozzle; the clamp required frequent adjustment to maintain an even discharge.

Descriptions of equipment that will dispense solutions at a constant rate were provided by Price and Haus (1963) who plumbed a 55-gal steel drum and Gresswell (1991) who drilled a hole in the pan of animal watering devices. Both apparatuses were designed to provide a fixed head to ensure no change in rate of discharge. Although these devices adequately dispensed piscicide, their bulk and weight limited their utility in areas inaccessible by vehicle. In addition, the dispenser described by Price and Haus (1963) was based on a drum with a side-mounted filler cap, which is not commercially available.

Our work on renovating streams for reestablishment of Gila trout *Oncorhynchus gilae* required removal of nonnative salmonids from streams that were up to 25 mi from the nearest road and were in wilderness areas (Propst et al. 1992). From the site, trail access to most stream reaches was limited. We needed dependable dispensers whose flow rate could be field-adjusted to provide an even flow for up to 3 h, were transportable by foot and pack stock, and did not require frequent attention. In addition, they had to be inexpensive, constructed with readily available commercial parts, quick to set up, rather indestructible to withstand transport, and easily maintained with simple tools.

We developed a simple device, similar to the portable Mariotte bottle described by Engstrom-Heg (1971), for dispensing liquid piscicide (antimycin A) and neutralizer (potassium permanganate) into streams at a uniform rate. A Mariotte bottle is an airtight container fitted with an outlet valve at the bottom and an air inlet tube that extends from the top to just above the valve. The liquid flows out at a steady rate as air enters through the inlet tube, thus equalizing internal and external air pressure. Because the head is fixed and equal to the vertical distance from the bottom of the air inlet tube to the outlet, discharge is constant (Engstrom-Heg 1971).

Our dispenser was constructed from commercial parts available at home supply stores and cost about US$6. Each unit consisted of a stackable 5-gal plastic bucket with an airtight sealable lid, a 1/4 × 1/8-in threaded brass needle valve inserted 1 in above the bottom of the bucket, and a 13-in length of 1/4-in outer diameter copper tubing inserted through the lid that extended to 2 in above the bottom of the bucket (1 in above the bottom of the needle valve) (Figure 1). To ensure a tight fit, the outlet valve was screwed into a hole slightly smaller than the threaded end, and the copper tubing was forced through a hole slightly smaller than the diameter of the tubing. Wrapping plumber's Teflon tape around the threads of the outlet valve and sealing the connection between the tubing and the lid with silicone caulk helped ensure a tight seal. During field applications, we adjusted the rate of flow from the dispenser to achieve the desired concentration of piscicide by making timed measurements into a graduated cylinder.

Laboratory tests at a regulated flow were conducted to determine whether discharge from the device varied over time. In these trials, the dispenser was assembled as just described, filled with tap water, and the lid securely seated onto the bucket. The outlet valve was opened and once flow stabilized, was adjusted to a test flow of 3.4 oz/min. This setting was not changed during the six

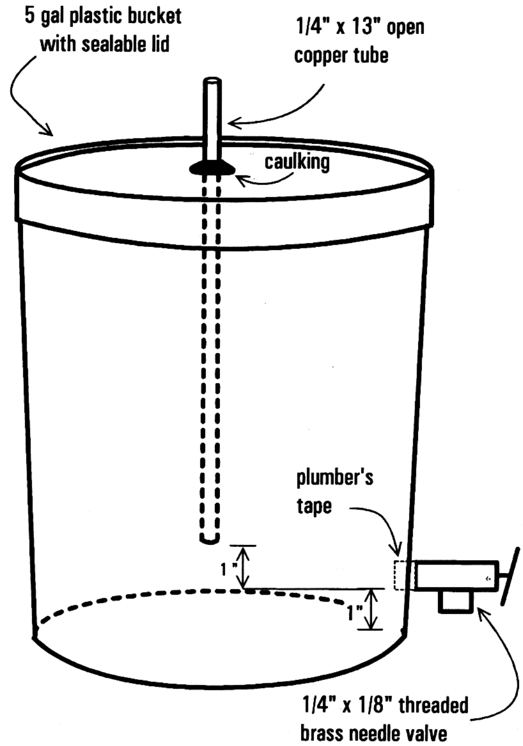

FIGURE 1.—Diagram of the constant-flow device. Measurements are in inches (″).

iterations of the experiment, nor the control. Discharge was measured with a graduated cylinder and stopwatch beginning at 15 and 30 min from the start of the test and thereafter at 30-min intervals until the container was emptied. As a control, the experiment was repeated but the air inlet tube was omitted. Discharge during the control test was measured as before.

Flow at each test of the regulated setting was relatively constant over time, although all showed a slight increase during the experiment (Figure 2), perhaps a result of the balance between internal and external air pressure changing as the height of the liquid fell. In all tests, the container was emptied in less than 3 h. In practice, 10 to 15% of the liquid is either retained in the container below the level of the outlet valve or is released unregulated before flow stabilizes; thus, the container will cease flow in slightly less than the calculated time. Tests at other flows (data not shown) produced a similar pattern. In the control test without the inlet tube, initial flow was high (13.5 oz/min) then declined to 4.9 oz/min at 30 min, and the container emptied within 60 min.

During field use, certain precautions must be

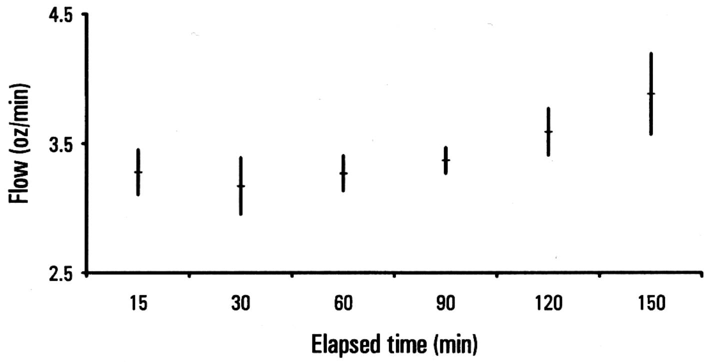

FIGURE 2.—Flow rates (mean ± SD) over time from a constant-flow device adjusted to dispense 3.4 oz/min (N = 6 test flows).

taken to ensure proper operation of the device. When the container is filled, the water should be passed through a coarse sieve to ensure that no particulate matter that could clog the needle valve is introduced. Also, the dispenser must be absolutely sealed with no air entering around the copper tube, the outlet valve, or the lid. In operation, a slight vacuum exists within the dispenser, and air entering elsewhere except through the bottom of the copper tube will disrupt the vacuum and affect the rate of flow. When the container is filled completely and properly sealed, flow will stabilize within a few minutes after the valve is opened. When properly operating, a faint "glug-glug" can be heard as air is drawn in through the copper tube. Different piscicides and neutralizers or their diluent or carrier may affect viscosity of the liquid and its rate of flow and should be accounted for during field use. Changes in water temperature (and therefore density and viscosity) may also produce varying flow rates.

We have used this apparatus on many stream treatments and found it to be reliable, economical, quick to set up, comparatively easy to transport, and reusable. Once properly operating at the desired discharge, the device requires no further monitoring or calibration. The laboratory tests indicated that it will provide a steady flow over time, thus ensuring a steady application of the piscicide to stream water. Our applications were on very small stream (flow rates <2 ft^3/s) where we applied piscicide during a 3-h period. However, one can use the device on larger streams by increasing the amount of piscicide in the container or changing the elapsed time of application. Nomographs and formulas are available to assist the worker in calculating the amount of piscicide required to achieve a desired concentration in the stream water (Price and Haus 1963; Stefferud et al. 1992). When using this constant-flow device, we recommend the worker experiment with different discharges to determine the best for a particular application.

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The constant-flow device described herein has evolved through many refinements during the past two decades. The improvements suggested by G. Ponder (deceased), D. Sada, D. Wong, and G. Burton contributed immeasurably to usability and effectiveness of the dispenser. This manuscript was improved by the comments of S. Stefferud, J. Rinne, and three anonymous reviewers.

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