TECHNICAL NOTE

A SIMPLE LIVE-WORM DISPENSER¹

Since fish will accept large numbers of live tubifex worms as reinforcers, it is possible to give several hundred trials in a single experimental session. To achieve this, however, it is necessary to use a food dispenser that is able to operate unattended for hundreds of trials. The machines developed by Hogan and Rozin (1961), Longo and Bitterman (1963), and Haralson and Ralph (1966) are cumbersome to load when adapted to supply a large number of reinforcers, and may be unreliable (Haralson and Ralph, 1966). The present device eliminates these disadvantages and is inexpensive and simple to construct. In discrimination situations, performance is often improved by delivering reinforcement close to the positive stimulus. In this dispenser, it is a simple matter to arrange outlets for the worms above each stimulus position. The machine could also be used for delivering daphnia or brine shrimp, either live or freeze-dried.

The principle of the dispenser is to prevent aggregation of the worms and to suspend them fairly uniformly in water by gentle stirring. They are then released in a controlled volume of water by the opening of an electrically operated valve in the floor of the stirring vessel (v in Fig. 1). In the version employed in this laboratory, the vessel is a 17-cm diameter polythene beaker, usually filled with water and worms to a depth of about 10 cm. Adequate stirring is achieved by rotating a flat aluminum paddle (8 by 13 cm) at about 50 rpm by an electric motor. After 20 min of stirring the worms tend to uncurl, but remain in apparently good condition and motile for several hours.

A simple and reliable valve consists of a stainless steel ball (b), 12.7-mm diameter, resting in a brass seating and covering a 6-mm diameter drain hole (d). When closed, the ball bears the weight of the iron core (c) of a solenoid (s). This arrangement ensures a good watertight seal in spite of any worms that may be trapped beneath the ball. A pulse of current through the coil of the solenoid raises the core about 3 mm, and with it the steel ball, thereby allowing 3 to 4 ml of water to flow through the drain. The average number of worms delivered may be adjusted (1) by a screw (a) limiting the travel of the solenoid core, and (2) by the length of current pulse in the coil. The timer con-

trolling the pulse length should have a range of 0.2 to 0.8 sec. A valve with dead-space is to be avoided because the worms tend to accumulate in the space, causing increased variability in the number of worms delivered on each occasion.

If the worms are considered as particles in a well-stirred suspension, the number appearing in each delivery should agree with a Poisson distribution. This was confirmed by applying a chi-squared test to the number of worms and fragments of worms counted over 100 consecutive deliveries.

Figure 2 shows the performance of two fish maintained by continuous reinforcement with the dispenser. The mean rate of delivery was three tubifex worms per reinforcement. The experiment was designed to determine visual thresholds using a tracking procedure. The fish, rudd (*Scardinius erythrophthalmus*), were trained to respond to the brighter of two stimulus patches. The tracking procedure consisted in raising the intensity difference by 0.2 log units following an

Fig. 1. Schematic diagram of the dispenser. See text for details.

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Fig. 2. Records produced by two fish, each in a single experimental session. These show stable tracking of the visual threshold on continuous reinforcement with the dispenser. See text for outline of tracking procedure. Intensity differences in the two light patches to be discriminated are represented on the vertical axis by 0.2 neutral density (N.D.) steps.

incorrect response, and reducing it by 0.2 following two successive correct responses. For details of the procedure see Muntz and Sokol (1967).

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