of *B. sphaericus* was based on the instar and age of the larvae, i.e., 2nd instar and early to middle-aged 4th instar larvae that fed on *B. sphaericus* were susceptible, while late 4th instar larvae that ceased to feed and pupated prior to ingestion of *B. sphaericus* survived the bacillus but succumbed to the effects of Arosurf MSF. Bioassays also indicated that effective dispersal of *B. sphaericus* over the surface of the water will result when Arosurf MSF is combined with water-base formulations of *B. sphaericus*. Blends of *B. sphaericus* and Arosurf MSF produced no synergistic effects; however, we suggest that joint action self-spreading formulations of *B. sphaericus* and Arosurf MSF can be used in dynamic *Cx. quinquefasciatus* and *Cx. nigripalpus* Theobald breeding situations such as sewage treatment systems where high concentrations of mixed larvae, pupae and emerging adult populations are usually found throughout the year. In addition, the recycling potential of *B. sphaericus* particularly in water containing high organic content (i.e., sewage treatment systems) makes this bacillus an excellent candidate for further formulation studies (Hertlein et al. 1979, Hornby et al. 1984).

References Cited

Anonymous. 1985. Informal consultation on the development of *Bacillus sphaericus* as a microbial larvicide. UNDP/World Bank/WHO Special Program for Research and Training on Tropical Diseases, 7–11 October 1985, Geneva, Switzerland, TDR/BCV/SPHAERICUS/85.3.

Burgess, J. H., R. Levy and T. W. Miller, Jr. 1985. A new method for applying Arosurf MSF (monomolecular surface film formulations). J. Am. Mosq. Control Assoc. 1:245–247.

Hertlein, B. C., R. Levy and T. W. Miller, Jr. 1979. Recycling potential and selective retrieval of *Bacillus sphaericus* from soil in a mosquito habitat. J. Invertebr. Pathol. 33:217–221.

Hertlein, B. C., J. Hornby, R. Levy and T. W. Miller, Jr. 1985. An injection method for spraying biological control agents and a monomolecular surface film for control of immature mosquitoes. J. Am. Mosq. Control Assoc. 1:255–257.

Hornby, J. A., B. C. Hertlein and T. W. Miller, Jr. 1984. Persistent spores and mosquito larvicidal activity of *Bacillus sphaericus* 1593 in well water and sewage. J. Georgia Entomol. Soc. 19:165–167.

Levy, R., C. M. Powell, B. C. Hertlein and T. W. Miller, Jr. 1984. Efficacy of Arosurf® MSF (monomolecular surface film) base formulations of *Bacillus thuringiensis* var. *israelensis* against mixed populations of mosquito larvae and pupae: bioassay and preliminary field evaluations. Mosq. News 44:537–543.

Levy, R., C. M. Powell, B. C. Hertlein, W. D. Garrett and T. W. Miller, Jr. 1982. Additional studies on the use of the monomolecular surface film Arosurf® 66-E2 for operational control of mosquito larvae and pupae. J. Florida Anti-Mosq. Assoc. 53:100–106.

AN AUTOMATIC CARBON DIOXIDE DELIVERY SYSTEM FOR MOSQUITO LIGHT TRAP SURVEYS

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The advantages of using carbon dioxide (CO_2) with mosquito traps were first described by Reeves (1951). In addition to increasing the total number of mosquitoes captured (Newhouse et al. 1966, Magnarelli 1975), the species composition of CO_2-baited traps more accurately reflects the true mosquito nuisance populations in an area (Parsons et al. 1974, Slaff et al. 1983). Generally, either dry ice or bottled CO_2 are used as the attractant in mosquito traps. A disadvantage of either source is that CO_2 is emitted for a far greater period of time than is desired, since the traps are usually placed long before sunset and retrieved well after sunrise. The system we describe offers regulated CO_2 delivery while providing timed switching for the CO_2 and light trap devices.

We connected an ASCO[3] solenoid, part no. 8210-093, powered by a 6-volt battery, to a standard single-stage CO_2 regulator using 3/8 in (9.5 mm) pipe bushing and 1/4 in (6.4 mm) pipe nipple (Fig. 1). A standard CDC photocell was wired to the solenoid.[4]

One benefit of the solenoid and photocell delivery system is that the unit may be set out and picked up during normal working hours. In addition, no CO_2 is wasted before or after the trapping period if the trap photocell and the CO_2 tank photocell are synchronized to initiate operation under the same lighting conditions. The photocell has a potentiometer adjustment that makes such a procedure straightforward. As a result, greater trapping time per CO_2 tank is possible, saving money and allowing an increase in the number of CO_2-

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[3] Automatic Switch Co., Florham Park, NJ 07932. Price $65.00.

[4] John W. Hock Co., P. O. Box 12852, Gainesville, FL 32604. Price $21.00.

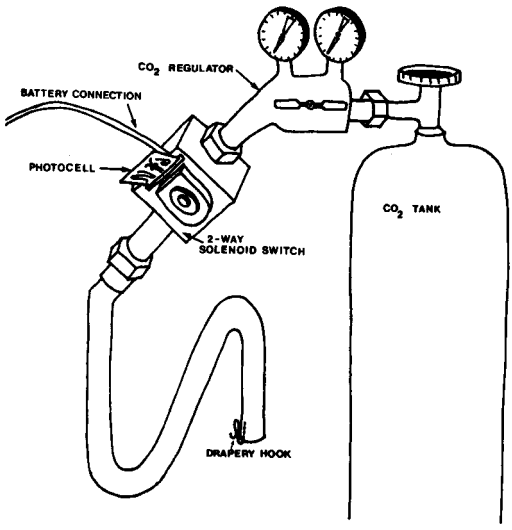

Fig. 1. A carbon dioxide delivery system with a photoelectrically operated 2-way solenoid switch.

baited trap nights. We consistently obtained 5 nights of trapping using 20 lb (9.1 kg) tanks with an emission rate of 2,500 ml/min. The temperature during our work ranged from 21 to 27°C, and each 9–10 hr night of trapping used ca. $0.95 worth of CO_2.

A mosquito trap with the described CO_2 delivery system provides an accurate, economical and consistent method to gauge nuisance mosquito levels.

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References Cited

Magnarelli, L. A. 1975. Relative abundance and parity of mosquitoes collected in dry ice baited and unbaited CDC miniature light traps. Mosq. News 35:350–353.

Newhouse, V. F., R. W. Chamberlain, J. G. Johnston Jr. and W. D. Sudia. 1966. Use of dry ice to increase catches of the CDC miniature light trap. Mosq. News 26:30–35.

Parsons, R. E., T. J. Dondero and C. W. Hooi. 1974. Comparison of CDC miniature light traps and human biting collections for mosquito catches during malaria vector surveys in peninsular Malaysia. Mosq. News 34:211–213.

Reeves, W. C. 1951. Field studies on carbon dioxide as a possible host stimulant for mosquitoes. Proc. Soc. Exp. Biol. Med. 77:64–66.

Slaff, M., W. J. Crans and L. J. McCuiston. 1983. A comparison of three mosquito sampling techniques in northwestern New Jersey. Mosq. News 43:287–290.

SUSCEPTIBILITY OF THREE SPECIES OF MOSQUITOES TO A PASTEUR INSTITUTE PREPARATION OF *BACILLUS SPHAERICUS* (STRAIN 2297)

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Bacillus sphaericus is a spore-forming bacterium, ubiquitous in nature, which grows readily on a variety of synthetic media and raw materials (Singer 1980). Some strains of *B. sphaericus* have a high level of insecticidal activity towards larvae of several mosquito species. This bacterium kills the mosquito larva by means of a toxin which accumulates rapidly during sporulation. Recycling can occur when spores germinate in the midgut of susceptible larvae, multiply vegetatively and produce fresh spores in the larval cadaver (Davidson 1984). This recycling provides a potential source of spores which may infect reinfesting larvae after the initial field treatment making this bacterium an ideal biocontrol agent.

There are no commercially available formulations of *B. sphaericus* and most of the experimental preparations currently being tested are developed in government and university laboratories (Lacey 1984). For this study, a lyophilized preparation of *B. sphaericus* strain 2297 serotype H25 (SPH 84), provided by the Pasteur Institute in 1984, was tested in laboratory against larvae of three of the major species of mosquitoes found in Fiji. The sample was first suspended in deionized water prior to the start of the tests. Field-collected *Culex quinquefasciatus* Say larvae and laboratory-reared *Aedes pseudoscutellaris* (Theobald) and *Ae. polynesiensis* Marks larvae were tested against this preparation at concentrations of 0.002, 0.003, 0.005, 0.008, 0.01, 0.02, 0.03 and 0.04 mg/liter. Twenty-five early 4th instar larvae were placed in each of the test dishes containing 150 ml deionized water and the appropriate *B. sphaericus* concentration. Four replicates were prepared for each concentration and a control population was run simultaneously. The experiment was conducted at 25°C and observations were made 24 hr after the application of the *B. sphaericus* preparation.

In addition, the tests against *Cx. quinquefasciatus* were repeated after the resuspended sample of *B. sphaericus* had been stored at 6°C for

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