Methods for the Field Release of Insect Parasites and Predators


ABSTRACT

BIOLICAL control of insect pests through the laboratory mass production and field release of insect parasites and predators offers a promising alternative to chemical insecticides. However, to be acceptable, biological control must not only be technically sound but must be economically competitive with other methods. Automated techniques which allow rapid and efficient releases of insect parasites and predators will be needed in many cases to ensure economic feasibility. In this paper we review nearly 10 yr of research into the techniques for releasing parasites and predators, much of which is previously unpublished. In addition, the methods and equipment used in the mechanical release of several species of beneficial insects are illustrated, and some of the biological and engineering aspects of insect releases are discussed.

INTRODUCTION

Under natural field conditions, insect parasites and predators or entomophaga as they are sometimes called, can have a large impact on insect pest populations, but frequently pest densities are not reduced to or maintained at economically acceptable levels, especially in areas where insecticides are widely used. Therefore, it may be desirable to supplement natural populations of beneficial insects through laboratory mass production and programmed releases.

Programmed releases of beneficial insects are of two broadly defined types. In the first type, inoculative releases of small numbers of parasites or predators produce relatively long-term effects on the pest population; whereas in the second type, releases of large numbers of beneficial insects inflict an immediate and direct effect upon the target pest (Stinner, 1977). Experimental and applied releases of both types have yielded variable results but have been successful enough to show high potential for use in pest management strategies (McMurtry et al., 1969; Ridgway and Jones, 1969; Ridgway et al., 1977; Arambourg, 1970; Stinner et al., 1974; Stinner, 1977).

Biological control programs using augmentation of parasites and predators usually involve three major operational phases. First, the parasites and predators and frequently their food sources must be produced in the laboratory. Secondly, the entomophaga must be transported to the release sites. During this transportation phase the insects must be maintained at favorable conditions of temperature and humidity. Also, if the release points are very distant from the production site, a remote field distribution laboratory may be required for temporary storage and pre-release preparation of the insects. The third operational phase involves distribution of the entomophaga over the target area. Mechanization in all three operational phases improves economic feasibility primarily through a reduction of labor input. However, this report will consider only the mechanization of insect releases.

During the last 10 yr the development of release methods for insect parasites and predators has been an evolutionary process from manual releases at ground level to almost fully mechanized aerial techniques. Perhaps a better understanding of the basic parameters of a release system can be obtained by a brief review of these developments and through a discussion of some of the attendant biological and engineering aspects.

GROUND-LEVEL RELEASES

The earliest methods used involved the release of entomophaga by hand from laboratory-prepared containers, or the manual placement of containerized insects at strategic points within the target area. Hand-release methods are still used by several commercial insectaries but they often require many man-hours of labor per unit of treated area.

Later, ground-oriented releases became more mechanized as methods were developed by which entomophaga were: (a) containerized and automatically dropped from a moving vehicle, (b) sprayed in liquid suspension, and (c) broadcast in various granular mixes. Each of these methods, though more efficient than manual releases, has certain drawbacks. Containerized insects that are dropped between plant rows are often exposed to extremely high ground-surface temperatures, frequently causing high insect mortality (Shands et al., 1972; Jones and Ridgway, 1976).

Eggs of predacious lady beetles and lacewings in a suspension of 0.125 percent agar were applied with a compressed air sprayer for control of aphids on potatoes in Maine (Shands et al., 1972). This method did not significantly reduce predator egg viability, but adherence
of eggs to foliage was low. In similar experiments in Texas (unpublished data, USDA-FR/SEA Cotton Insects Research Laboratory), adverse effects of liquid formulation materials have severely reduced the viability of *Trichogramma* wasps, an important parasite of cotton bollworm and tobacco budworm eggs. Therefore, suspension in liquids is not currently practicable with some entomophagous species.

Two methods of applying a mixture of sawdust and predacious larvae of a green lacewing to cotton plants were developed and evaluated in Texas during the early 1970's (Reeves, 1975; Kinzer, 1976). First, a backpack release unit constructed of a D-Vac® carrying frame, a Noble® granular applicator hopper, and a Cyclone® seeder metering unit powered by a 12-V D.C. motorcycle battery (Fig. 1) was used to release the predators at a rate of 247,000/ha (Reeves, 1975). Suppression of the target pest population was significant; predator injury was low, and adherence of the predators to foliage was satisfactory (Kinzer, 1976). However, because a 2-man crew could treat only 0.2 ha/h this method proved unfeasible. In terms of man-hours of labor the second method, employing a 4-row motorized unit mounted on a Hahn Hi-boy® sprayer chassis (Fig. 2), was 85 percent more efficient (Reeves, 1975).

Ground-level release methods are useful for research purposes in that basic release parameters such as the optimum spacing of entomophaga and numbers required to obtain the desired pest mortality can be more easily estimated. However, ground releases are subject to limitations like inaccessibility of release areas in wet weather, damage to crops by machinery, and low dissemination of insects per unit of time.

**AERIAL RELEASES**

Aerial release techniques circumvent some of the basic problems encountered with ground-release methods. Because target areas often consist of hundreds or even thousands of hectares, timeliness of the release is critical. In addition, many entomophaga, to be effective, are best released only at certain times during the day (usually early morning or late afternoon), and thus more attention to timeliness is necessary. Therefore, aerial releases will often be the only practical method for commercial-size farming operations.

The earliest aerial release methods consisted of timing, with a stopwatch, the distance intervals between distribution points and merely dropping packaged insects out of the aircraft door (Schuster et al., 1971). Later, equipment such as that employed in sterile insect release programs (Boving et al., 1969; Higgins, 1970) was used to mechanically eject packaged entomophaga from the aircraft (Schuster et al., 1971).

At our laboratory, packaged *Trichogramma* wasps have been released into cotton fields by using a portable machine installed in the cabin of a Cessna 180® aircraft (Fig. 3). The machine had a refrigerated storage compartment and automatically opened and released the insect packets at the rate of 158.4/min or 43.2/ha. Parasite efficiency was equal to that in ground releases while man-hours of labor were reduced 94.3 percent by this automation (Reeves, 1975).

Although the aerial release method just described represented a significant advancement in release technology, several problems still existed. Packages for insects are costly, and the labor and space requirements associated with packaging are too demanding. Furthermore, the placement of large numbers of packages at uniform, widely spaced points in the field requires that the parasites or predators obtain an adequate distribution through their natural powers of dispersal. Under these conditions, the natural enemies may often disperse completely out of the area. Therefore, bulk
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FIG. 4 Unit for the aerial release of lacewing larvae in a sawdust mixture.

handling and broadcast release of parasites seem more desirable.

There are few examples of automated free aerial releases of entomophaga. At our laboratory an aircraft attachment consisting partly of a Venturi spreader was used to release green lacewing larvae in a sawdust mixture (Fig. 4). Final analysis indicated that commercially available equipment for applying dust or granular pesticides was adaptable for these releases. However, possible contamination of entomophaga by chemicals in used equipment must be considered (Reeves, 1975).

In a recent example of automated free release (Ridgway et al., 1977) parasitic flies were distributed over about 810 ha in Florida for control of sugarcane borer. The equipment used was the same as that for release of sterile pink bollworm adults (Higgins, 1970). Basically, the machine is a refrigerated box with a mechanism for storing and metering out the insects at the desired rate (Fig. 5). The machine was mounted to the side of an aircraft and remotely controlled by the pilot. During operation the insect storage trays were released independently and the parasites fell into the metering unit. The parasites were conveyed from the refrigerated box into an outlet tube by means of a variable speed endless belt located in the metering unit.

In some cases bulk handling and free release may require that the insects be distributed in some inert dispersal medium (liquid or granular mixes) to allow accurate metering and precise placement of the insects onto plant foliage. We have recently employed such methods to release Trichogramma onto cotton with an experimental backpack unit (Jones et al., 1977), and from an agricultural aircraft (Jones et al., unpubl. data). With an adhesive solution, individual parasitized host eggs were uniformly attached to wheat bran flakes, loaded into the applicator hopper, and broadcast over cotton fields in a manner much like a granular pesticide. The advantages of this new technology include: (a) decreased cost of parasite preparation and release, (b) use of existing conventional agricultural aircraft and equipment, (c) increased parasite efficiency, and (d) a considerable reduction in the number of parasites required for release.

The design and use of insect-release equipment must take into account the biological properties of the insects to be released as well as the engineering aspects, both of which ultimately relate to the economic feasibility and overall effectiveness of the release program.

BIOLOGICAL AND ENGINEERING CONSIDERATIONS

In the foregoing discussion we have touched upon most of the biological considerations for releases of entomophaga. In summary these are: minimum injury to the entomophagous species, optimum spacing of entomophaga within the target area, release of adequate numbers to ensure the desired pest mortality, timeliness, and adherence to plant foliage.

Whenever possible, existing equipment should be adapted for insect release so that research and development cost is minimized. Several types of equipment developed for release of sterile insects (Boving et al., 1969; Higgins, 1970; McMechan and Proverbs, 1972) have been adapted for parasite releases, but these devices are not suitable for certain entomophagous species.

Choice of appropriate aircraft is obviously important in aerial release methods. Aircraft should be evaluated in regards to flight capability both in terms of range and low level maneuverability. Cabin and cargo space is also important. Some insects may be subjected to injury when released from fixed-wing aircraft (Steiner et al., 1963), and use of helicopters traveling at slower
air speeds may reduce this effect. Further, optimum speed and level of flight must be determined.

Design of the actual distribution machinery is most important. This equipment should be compact and lightweight to facilitate loading and unloading at the airstrip and to minimize aircraft fuel consumption. Heat and vibrations from machinery functions may harm the insects, and this must be considered in equipment design. Because time is a major limiting factor, equipment should have a high hourly release capacity—for example about 80 ha/h (Reeves, 1975). Numerous other factors will no doubt require consideration depending upon the insects to be released, the amount of area to be covered, and the number of insects per unit area required for maximum effectiveness.

In summary, entomological and engineering technology that is necessary for successful release programs continues to progress. However, to attain the goal of economic feasibility through mechanization, more engineering input is needed. Through closely coordinated interdisciplinary research and communication we can achieve this goal.

References


