MASS REARING TECHNOLOGY FOR BIOLOGICAL CONTROL AGENTS OF *LYGUS* SPP.[1]

Rebecca A. Smith and Donald A. Nordlund

USDA, REE, ARS, MSA, Biological Control and Mass Rearing Research Unit
P.O. Box 5367, Mississippi State, Mississippi 39762-5367

ABSTRACT

Lygus lineolaris (Palisot de Beauvois), the tarnished plant bug, and *Lygus hesperus* Knight, the Western tarnished plant bug, are important pests of many crops in the Eastern and Western United States, respectively. Alternatives to conventional insecticides for control of these pests are of increasing interest, in part because of the advance of the boll weevil eradication program and the introduction of transgenic plants. Several parasitoids and predators are candidates for use in augmentative biological control, as a component of area wide IPM for *Lygus* spp. management. These include the parasitoids *Anaphes iole* Girault, *Peristenus stygicus* Loan, and *Leiophron uniformis* (Gahan); and the predators *Geocoris punctipes* (Say), *Orius insidiosus* (Say), and possibly even *Chrysoperla* spp. To be useful, these natural enemies must be available in large numbers, and thus arises the need for mass rearing techniques. Currently, even for those species that are available from commercial sources, rearing systems do not have the capacity to produce these insects in sufficient numbers to support biological control of *Lygus* spp. in crops such as cotton. This paper reviews some of the progress that is being made in the development of up-scaled systems for rearing both *Lygus* spp. and predators and parasitoids that attack these important pests.

INTRODUCTION

Lygus lineolaris (Palisot de Beauvois), the tarnished plant bug TPB , and *Lygus hesperus* Knight, the western tarnished plant bug (WTPB), are important pests of many crops in the Eastern and Western United States, respectively. There is increasing interest in the development of alternative approaches for managing these pests, in part because of the advance of the boll weevil eradication program and the introduction of transgenic plants. Among the alternative approaches with some promise is augmentative biological control. The primary approach to augmentative biological control, periodic release of biological control agents (inoculative or inundative releases) (Nordlund 1996), is dependent on the availability of large numbers (millions, billions, or even trillions) of high quality and low cost organisms for release (Nordlund 1998). Though quality of biological control agents continues to be a concern (Hoy et al. 1991; van Lenteren 1991; Cranshaw et al. 1996; Losey and Calvin 1995; O'Neil et al. 1998), the focus of this paper is on efforts to increase the rearing capacity and reduce the costs of mass rearing entomophages with

[1] Mention of a commercial or proprietary product does not constitute an endorsement by the USDA.

potential as biological control agents for *Lygus* spp. (Ruberson and Williams 2000) and *L. hesperus*, which is used to support *in vivo* rearing of parasitoids.

Artificial diet is of great importance to the scale-up of an insect mass rearing system, even if only for the pest. An artificial diet facilitates mechanization, generally reduces the complexity of the system, and reduces the cycle time (the time from initial setup until the final product is obtained). In addition, rearing millions, billions, or trillions of insects requires some level of mechanization and automation. In a mass rearing system, mechanization can reduce the labor required to perform a function, increase the speed with which a function is performed, increase the number of operations that can be performed at one time, increase production capacity, result in a higher quality insect, and reduce the chance of human error. Recent reviews related to these issues include Cohen et al. (1999), Nordlund (1999), Smith and Nordlund (1999), Smith (1999). A variety of technologies are needed to achieve significant increases in rearing capacity and reductions in rearing costs for potential *Lygus* spp. biological control agents, permitting the development of effective biological control strategies for these pests. Technologies for mixing, packaging, and presentation of artificial diet; mixing and packaging Gelcarin® (FMC, Philadephia, PA) for *L. hesperus* oviposition; efficient holding cages for *L. hesperus*, *Anaphes iole* Girault, *Geocoris punctipes* (Say), and *Orius insidiosus* (Say); systems for capturing and counting insects; systems for efficiently exposing hosts to parasitoids; systems for collection of parasitoids, and systems for field release of both parasitoids and predators are needed. We will review some of the progress being made in the development of these technologies.

PREDATORS

The predators *O. insidiosus*, *G. punctipes*, and *Chrysoperla* spp. are currently available from commercial sources (Hunter 1997). These predators can be reared on artificial diet such as those developed by Cohen and Urias (1986) or Cohen and Smith (1998), though an efficient artificial diet for *O. insidiosus* must still be developed.

Chrysoperla are available in relatively large numbers, though most commercial rearing is still based on the use of *Sitotroga* or *Ephestia* eggs. The rearing system for *Chrysoperla* is developed enough to allow significant commercial availability of these predators, which are widely used in high value crops. However, costs could be further reduced and capacity increased by the very effective artificial diet recently developed and patented (Cohen and Smith 1998; Cohen 1998). Also, the introduction of an automated system for efficient diet packaging and a more efficient way of placing eggs into the larval rearing units would contribute significantly to increasing capacity and reducing costs. Solutions to these shortcomings in the *Chrysoperla* rearing system are being developed. Nordlund and Correa (1995) developed a more efficient way of holding *Chrysoperla* adults, using cubic rearing boxes, and harvesting their eggs using a sodium hypochlorite solution. An improved system for preparing the larval rearing units was also developed (Nordlund 1993). These techniques lend themselves to mechanization, and thus, the *Chrysoperla* rearing system is probably the entomophagous insect rearing system that is closest to being fully mechanized.

An effective artificial diet for *G. punctipes* has been available for over 15 years (Cohen and Urias 1986, Cohen and Staten 1994), but there has been little effort to develop a cost effective mass rearing system for this potentially valuable predator. One problem with the *G. punctipes* rearing system is that the current Parafilm M® (American National

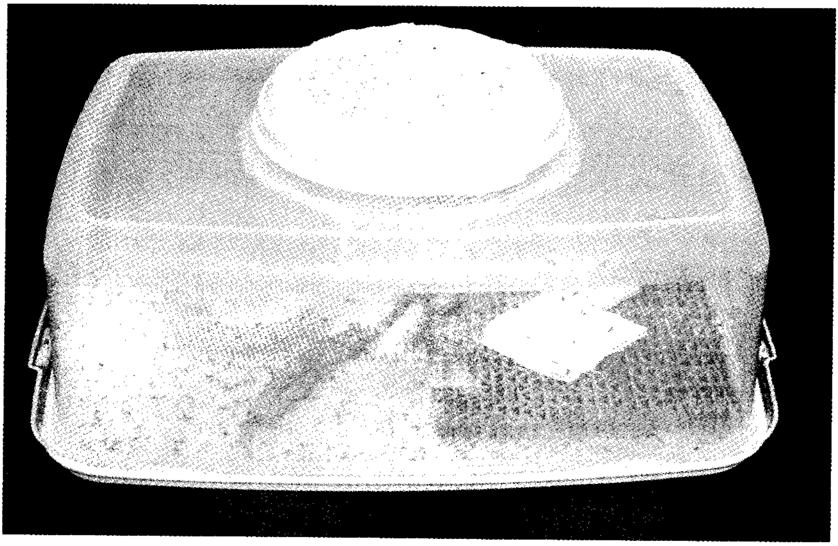

FIG. 1. Current modified Rubbermaid 2.2 U.S.Gal./8.3 l Servin' Saver and 1.7Qt/1.6l Servin' Saver combination used in *Geocris punctipes* rearing.

Can, Chicago, IL) diet packets must be hand-stretched to facilitate nymphal feeding. When done by hand, this is an extremely time consuming process, especially when hundreds of rearing containers must be serviced daily. Alternatives to stretched packets are being tested. Another problem is the box (a modified Rubbermaid® 2.2 U.S. Gal./8.3 l Servin' Saver® and 1.7 Qt./1.6 l Servin' Saver combination) currently used for holding *G. punctipes* nymphs and adults (Fig. 1). Using such small boxes, in which food, water, and ovipositional substrate must be changed daily, requires considerable labor. Tests of a system that will provide food, water, and ovipositional substrates under a much larger container are being conducted. A third problem that needs to be solved for mass rearing *G. punctipes* is harvesting of the eggs from the ovipositional substrate, which is currently a piece of flannel material. Currently, the pieces of flannel on which the eggs have been oviposited are simply placed into a new container to start a new rearing box. However, the eggs can not be efficiently counted, and such a system is not suitable for shipment of eggs. Alternative oviposition substrates are being tested.

O. insidiosus are also currently being reared in Rubermaid boxes like those used for *G. punctipes*. Larger rearing containers need to be tested. *O. insidiosus* are fed from the top of the container, but water is still provided inside the box, as are the green beans, which serve as the oviposition substrate. It is extremely difficult to obtain quality green beans year-round, so an artificial ovipositional substrate is a major need for *O. insidiosus* mass rearing. Castañé and Zalom (1993) discovered that a gelatin substance covered with a thin layer of paraffin can be used as an artificial ovipositional substrate for *O. insidiosus*. However, the thickness of the paraffin layer is critical to the success of this artificial medium. Further research into this type of ovipositional substrate is planned.

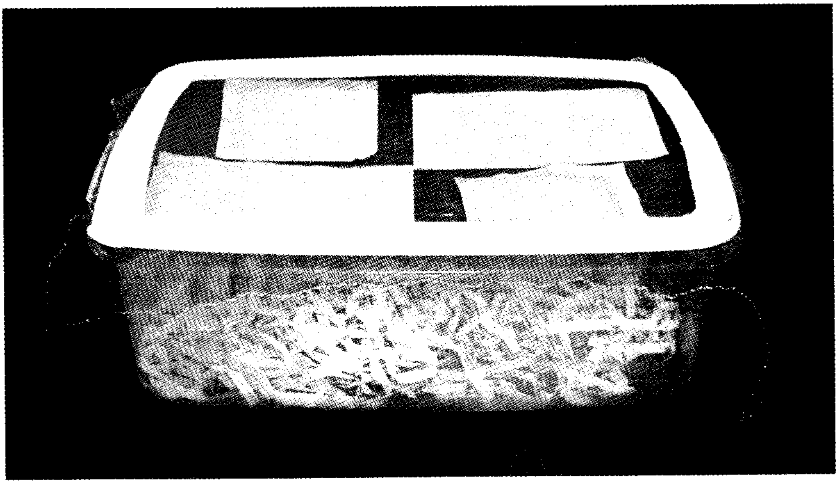

FIG. 2. Modified Rubbermaid 2.2 U.S. Gal./8.3 l Servin' Saver currently used in *L. hesperus* rearing. Note the artificial diet and Gelcarin oviposition packets on the top.

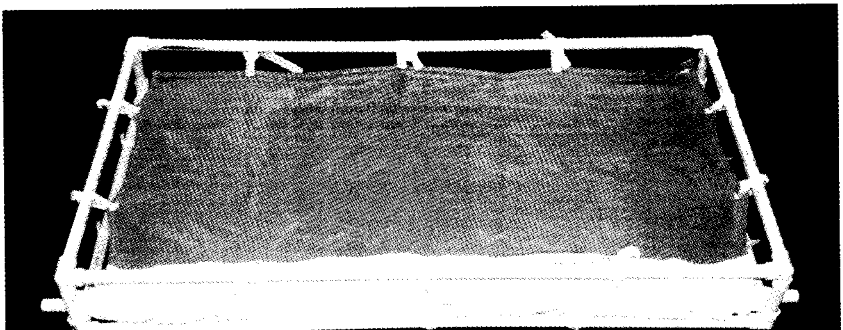

FIG. 3. Prototype of new *L. hesperus* cage.

Parafilm, which still had to be removed before the packets could be used for feeding the WTPB. These systems were also used to make the oviposition packets that were filled with Gelcarin. A sealing system that will automatically form, fill, and seal the diet and oviposition packets is being developed. It will seal the packets without the paper backing on the Parafilm, which will remove another step from the package making process.

Currently, our *Lygus* colony is being reared in modified Rubbermaid 2.2 U.S. Gal/8.3 l Servin' Savercontainers (Fig. 2). Each container holds only approximately 1,000 adults and during the rearing process there is a need to consolidate cages to insure that they contain enough adults. Thus, labor for handling and servicing the containers is an important cost factor.

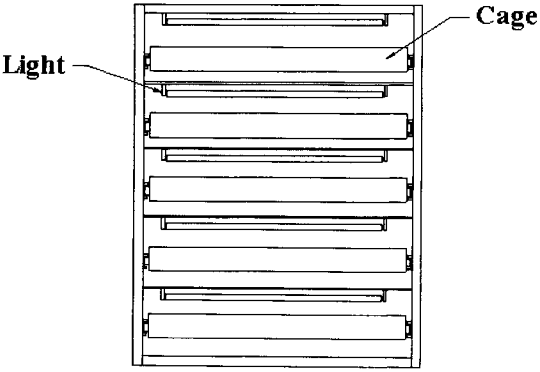

FIG. 4. Preliminary design for up-scale *L. hesperus* holding system.

Also, the rearing space is used inefficiently. A new, larger cage (Fig. 3) that will be incorporated into a rack-drawer type of system (Fig. 4) is being developed. Each large cage will replace approximately seven of the smaller containers. The cage is made, primarily of Lumite® woven synthetic fabric, Style - 5006200 (Synthetic Industries, Gainesville, GA) mounted on a PVC pipe frame. This allows the cages to be washed in a washing machine, for easy clean up. The Lumite material of the new cage is of a mesh size that prevents 1st instar nymphs from escaping but allows feeding and oviposition. Once set up, the only service this new cage requires is changing of the diet and ovipositon packets.

To mass rear *Lygus* spp. to support *in vivo* rearing of parasitoids for use in biological control programs, an efficient way of counting and harvesting the eggs from the Gelcarin packets must be available. This is especially true for egg parasitoids, since the parasitized eggs must be removed from the Parafilm to enable the parasitoid to emerge.

CONCLUSION

Use of augmentative biological control techniques for *Lygus* spp. management will require large numbers of parasitoids and/or predators. There are currently no "mass rearing" systems in place for any predator or parasitoid of *Lygus* spp. capable of producing the number of insects required for practical use in crops such as cotton, which cover very large areas. Rearing systems for the predators, especially *Chrysoperla* and *Geocoris*, are quite possibly the closest to being capable of producing insects in sufficient numbers. The areas which require immediate attention are scaling up the WTPB diet production and packaging systems and developing efficient holding systems for the pests, predators, and parasitoids. Once these important problems have been solved , we will be well on our way to being capable of rearing large numbers of *Lygus* and their predators and parasitoids.

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