EXPERIMENTAL CONFIRMATION OF THE BRUCHIDAE NATURAL PARASITISM EFFICACY USING AN INNOVATIVE DEVICE, FRIENDLY TO THE ENVIRONMENT

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ABSTRACT
Due to the high cost factor the existing methods of managing pests in stored grains are not feasible for small-scale farmers. Management of pests by using locally and naturally available materials will be affordable by farmers and it will also be environment-friendly. In the present work, an innovative device (parasitoid facilitator bin), friendly to the environment with provision for the free movement of parasitoids into the bin was designed and employed to manage one of the major pests of pulses, the cowpea weevil, Callosobruchus maculatus (F.). The parasitoids that naturally entered the experimental setup were the egg parasitoid, Uscana lariophaga (S.) and the larval and pupal parasitoid, Dinarmus basalis (R.). The number of pests (all life stages) gradually decreased in grains stored in bins where there was provision for the movement of natural parasitoids. Adult emergence was very high in the control (320 to 416 per 500 egg-carrying grains), whereas it was much lower (33 to 46 per 500 egg-carrying grains) in the experiment, i.e. in the parasitoid facilitator bin. The adult emergence inhibition index in the experiment was 81.21%. In areas where natural parasitoids are abundant, this bin can be a boon to the farmer and this may have practical implications in the development of efficient large-scale storage systems.


Keywords: environmentally-friendly device, natural parasitism, biological control, Callosobruchus maculatus, Uscana lariophaga, Dinarmus basalis

Introduction
In addition to the loss of grains in the field, damage of grains happens during storage due to the non-availability of proper structures for large-scale storage and efficient pest management practices especially in developing and underdeveloped countries. The management of pests of stored produce is highly challenging since the pests occur in food grains and chemical treatments affect the organoleptics of the product. Treatment of food commodities should be moderate so as not to affect the gustatory characteristics and acceptability of the treated material (3, 6).

Stored-grain insect pests are managed by methods requiring high inputs like costly chemical insecticides, botanical pesticides, biological and physical control methods, often unaffordable by small-scale farmers (12, 13). Normally, food grains and pulses are stored in steel and polyester bins under controlled conditions, after being subjected to gamma irradiation, freezing or heating (8). Bruchid and curculionid pests are the most difficult to tackle. Internal feeders such as Callosobruchus maculatus Fabricius, 1757 (Coleoptera: Bruchidae) is a highly destructive secondary pest of stored produce with a wide host range and is an important pest of stored agricultural products in many countries such as India (6) and Greece (11), affecting commodities both quantitatively and qualitatively. The pulse beetle infests a wide spectrum of pulses (3) and destroys protein reserves meant for human consumption. Often, the pests are carried over from the field when pulses infested with eggs, larvae or pupae of bruchids are stored. Filling warehouses with pest-infested pulses results in the total loss of stored pulses within 2-3 months (10).

A number of hymenopteran parasitoids of stored-produce pests are found in the field, but it is difficult to use them for managing pests in closed environments, since they require nectar for sustenance and near-natural conditions for proper reproduction (15). A storage bin that facilitates parasitoids should allow their free inward and outward movement. In this study a parasitoid facilitator bin with provision for such free movement of parasitoids was designed and employed to manage one of the major pests of pulses, the cowpea weevil, C. maculatus on green gram (Vigna radiata L.; mung bean).

Materials and Methods
In the present study, the laboratory work was carried out at the Department of PG Studies and Research Centre in Zoology at Scott Christian College (Autonomous), in Tamil Nadu in south India and farm-level testing, was carried out in the nearby farm area Parvathipuram.
Green gram was purchased from local farmers (local variety – susceptible to *C. maculatus*) and sun-dried for a day. The sun-dried seeds were stored in a freezer at -18°C for two days. Based on the requirement, the seeds were taken from the freezer and subsequently dried in a hot air oven at 60°C for about a week to guarantee the absence of any viable insects without having to use chemicals. The seeds were stored in air-tight plastic containers at room temperature before use. Only visually uninfested seeds were used for the experiments.

New hatched *C. maculatus* (1-1.5 h old) were separated from the stock culture and allowed to mate inside glass jars. From this, 30 newly mated females were released into a glass jar (diameter 15 cm) containing 700 laboratory-preconditioned *V. radiata* seeds and allowed to remain in the jar for 24 h (to lay eggs) and removed soon after by using an aspirator. (Broad glass jars were used to enhance the diameter, thereby decreasing the depth of grains ensuring uniform oviposition and minimizing over-egg laying, which resulted in reduced larval competition). Then the egg-carrying grains (500 grains with a single egg per grain) were gently transferred to the parasitoid facilitator bin. For control, the same quantity of egg-carrying grains was kept in another bin closed with a non-perforated lid.

Each experiment set had fifteen replicates and maintained at a temperature of 30 ± 3°C, relative humidity 70 ± 5% and natural photoperiod in the laboratory. The experimental set up was kept undisturbed for 25 days in an accessible location to facilitate parasitization by the parasitoids naturally present in that area. The adult emergence inhibition index (AI) was calculated from the formula (4): $AI (%) = \frac{(C - E)}{(C + E)} \times 100$, where $C$ is the number of adults emerged in control and $E$ is the number adults emerged in experiment (parasitoid facilitator).

**Results and Discussion**

In this study, parasitoids naturally entered the experimental set up and parasitized the eggs, larvae and pupae of *C. maculatus*. The parasitoids were collected and identified using the key by Haines (3). The egg parasitoid sampled from the parasitoid facilitator was *Uscana lariophaga* Steffan, 1954 (Hymenoptera: Trichogrammatidae) and the larval and pupal parasitoid sampled was *Dinarmus basalis Rondani*, 1877 (Hymenoptera: Pteromalidae).

The number of *C. maculatus* (all life stages) gradually decreased in grains stored in bins where there was provision also. The most important part of the bin is its metal lid with uniformly spaced holes (1 mm diameter) drilled onto it. These holes provide easy access for hymenopteran egg and larval parasitoids to the bin. The parasitoids easily passed through the holes into the bin and parasitized the eggs, larvae and pupae of *C. maculatus*.

**TABLE 1**

<table>
<thead>
<tr>
<th>Container</th>
<th>Storage period (week)</th>
<th>Number of adults emerged</th>
<th>Percentage of adults emerged</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Parasitoid Facilitator X ±SD</td>
<td>7.2 ±0.75a</td>
<td>4.4 ±0.49a</td>
<td>2.6 ±0.49a</td>
</tr>
<tr>
<td>Sealed X ±SD</td>
<td>8.4 ±0.8b</td>
<td>8.2 ±1.3b</td>
<td>7.2 ±0.98b</td>
</tr>
</tbody>
</table>

Differences between containers are denoted by different letters. P≤ 0.05 level (t – test)

Percentage of Adult Emergence Inhibition is 81.21
for the movement of natural parasitoids. When 10 grains were checked at random, live larvae were found in 7-8 grains during the first week of storage in a bin carrying a parasitoid facilitator lid, and in 7-9 grains in the control bin with non-perforated lid. The live larval and pupal count decreased significantly in the parasitoid facilitator bin as the storage duration was prolonged to 4 weeks (1-2 life stages per 10 grains in the parasitoid facilitator bin and about 7-10 life stages per 10 grains in the control bin). Adult emergence was very high in the control bin (320-416 per 500 egg-carrying grains), whereas it was much lower (33-46 per 500 egg-carrying grains) in the parasitoid facilitator bin (AI = 81.21% (Table 1). In stored produce protection, there is increasing interest in the development of biological methods for pest control (1, 19). The advantage of using beneficial insects to combat storage pests has been widely recognized in the past two decades (1, 2). The advantages are: (i) they do not leave synthetic residues on the stored commodities; (ii) they are safe to non-target organisms; (iii) the chances of pests developing resistance are low; (iv) the antagonists either occur naturally or can be applied safely by unskilled workers; and (v) they can be self-perpetuating, ensuring prolonged control of stored products (21).

The investigators (16, 17, 18, 20, 21) studied the efficacy of the parasitoids Usca na lariophaga (egg parasitoid; Hymenoptera: Trichogrammatidae) and D. basalis (larval and pupal parasitoid; Hymenoptera: Pteromalidae). Management of the bruchid, C. maculatus, using these parasitoids will be more efficient if proper storage bins are available. The parasitoid facilitator bin developed here is a relatively simple structure with a pest-excluder lid. The lid is perforated with openings having a diameter of 1 mm, which allows in parasitoids such as Usca na sp., Dinarmus sp. and Euplemus sp. while preventing the entry of C. maculatus. This was clear from a random observation of grains over a period of 4 weeks, the time sufficient for the development of C. maculatus.

A very small number of adults (40 ± 5 per 500 egg-carrying grains) emerged from bins provided with parasitoid facilitator lid, whereas about 400 adults per 500 egg-carrying grains emerged from control bins sealed with non-perforated lids. The parasitoid facilitator bin exploits the natural availability of parasitoids under field conditions, and the small pores (1 mm diameter) do not allow the entry of most of the common insect pests. In areas where natural parasitoids are abundant, this bin can be a boon to the farmer.

Although many species of parasitic wasps have been recorded worldwide in association with beetle and moth pests of stored products, most of these are rare or occasional. The great majority of parasitoid species recorded from tropical stores belongs to the family Braconidae and Pteromalidae. Dinarmus basalis (Pteromalidae) is a parasitoid of pests of stored products of the family Bruchidae, especially Callosobruchus sp., in many parts of the tropics (3).

The parasitoid facilitator bin used in this study facilitates the inward and outward movement of parasitoids, leading to the augmentation of parasitoids, enhancing the rate of parasitism. When the host eggs or larval stages increase inside the bin, the parasitoids in the field are attracted and the life stages of the pest get parasitized, leading to quicker reproduction of the parasitoids, eventually resulting in the mass biological control of C. maculatus. The parasitoids control the pests of stored produce at the initial stage itself as they have a high host-searching ability. Consequently, parasitoids can effectively take care of the grains stored by the farmers.

The egg parasitoid Usca na sp. has high fecundity (36.4 ± 2.1), high mating ability (males mate about four times in their life time, females need only one copulation to complete their oviposition), short lifespan (12 days – larval period 7 days and adult lifespan 5 days), high adult emergence percentage (72%), high host-searching ability and the ability to complete its larval stage inside an egg itself (5). Pteromalids (larval and pupal parasitoids) were able to distinguish infested cowpea seeds from non-infested seeds since increases in the number of non-infested seeds did not lower the number of bruchid larvae parasitized (7). Some odour sources such as bruchid sex pheromone, oviposition marker pheromone and infested seeds have been observed to generate a positive olfactometry response (9). It is probable that the ultrasonic vibrations generated by the internally developing larvae (14) may be used for detecting larvae-bearing seeds (7).

Temperature (30°c and above), package of grains inside the bin (tightly packed) and depth (larger bin), feeding adult and closed environment are the important limiting factors of parasitism by the parasitoids. These shortcomings can be overcome by using the parasitoid facilitating bin. When the number of pests decline, the parasitoids need not die as in a closed system. But they can move out through the perforated lid and search for parasitizing other sources. As C. maculatus has the habit of laying eggs on the surface of stored pulses, it is appropriate to have pores in the lid. For other pests and large-scale storage, this bin can be modified by making pores all over the bin.

This is advantageous to tribals and farmers as regards farm-level storage. It can easily be adopted in the developing and underdeveloped nations, where proper storage structures for farm-level warehousing are unavailable and the biodiversity of parasitoids is high.

Conclusions

The mentioned method of management might be very successful in large-scale storage, especially for pulses stored with small intergranular spaces. Storage methods, parasitoids and pests vary based on the commodities stored. Further research is needed to design appropriate storage structures (based on the behaviour of pest and predators related to the storage structure – to enhance the searching ability of parasitoids and to reduce the host-locating or ovipositing behaviour of the pest) to
enhance biocontrol of storage pests using parasitoids present naturally or introduced.

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REFERENCES