Host location and distribution of *Anisopteromalus calandrae* (Howard) (Hymenoptera: Pteromalidae), a larval parasitoid of maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae)

Sitthichaiyakul, S.#[1,2], Amornsak, W.*[1]
[1]Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand
[2]Postharvest Technology Research and Development Group, Postharvest and Product Processing Research and Development Office, Department of Agriculture, Bangkok 10900, Thailand

*Corresponding author, Email: agrwwa@ku.ac.th
#Presentting author, Email: lepido_aom@hotmail.com

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Abstract

Anisopteromalus calandrae (Howard) (Hymenoptera: Pteromalidae) is a solitary larval parasitoid of the maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). This larval parasitoid was also reported as a potential biological control agent for other stored-product insects, including the rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) and angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae). Knowledge, behavior and host location ability of parasitoids is limited and must be determined. Distribution of *A. calandrae* is also a factor involving host location. Consequently, we designed a model silo to investigate host location and distribution of *A. calandrae*. This silo model was designed using a plastic box (15x7x21.5 cm) with four floors/chambers, 0, 5.5, 11, 14.5 cm as the first, second, third and fourth floor from the bottom, respectively. A sieve (1 mm diameter holes) was inserted between each chamber. A mixture of uninfested (90 g) and infested brown rice (30 g) with 21 day-old *S. zeamais* larvae were placed on the sieve of each chamber. Fifty pairs of *A. calandrae* were released through a hole on the top of the silo model. Three days later *A. calandrae* adults were removed from the chamber. Silo models were held for two weeks and numbers of progeny were counted. We found the fourth chamber had the highest number of *A. calandrae* while the first chamber had the lowest number. The results showed that *A. calandrae* could disperse throughout the silo model but it preferred to lay eggs within the upper chamber.

Keywords: *Anisopteromalus calandrae*, *Sitophilus zeamais*, larval parasitoid, host location, distribution

1. Introduction

Stored-product insects are found in a variety of grain storage and food processing facilities, where they damage various cereal grain, pulse, animal feed and grain products. The maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) is a key stored-product pest and its larvae develop as internal feeders of stored grain. Grain loss involves quantitative and qualitative factors. Many countries such as Kenya (Likhayo and Hodges, 2000), Saudi Arabia (Ahmed, 1996) and Brazil (Guedes et al., 1995) use fumigants such as methyl bromide and phosphine for controlling stored-product insects. Currently methyl bromide is being phased out as a control for insect pests in storage and other commodities because of its effect on ozone in the atmosphere. Some stored-product insects can survive phosphine fumigation and become resistant to the compound.

Biological control using natural enemies is an alternative technology for suppressing stored-product insects (Steidle et al., 2003). *Anisopteromalus calandrae* (Howard) (Hymenoptera: Pteromalidae) is a larval solitary ectoparasitoid which has potential as a biological control

agent for controlling some stored product pests. *Anisopteromalus calandrae* is a native parasitoid used to control *S. zeamais* in Thailand.

Many stored-product insect species (e.g. *Crytolestes ferrugineus* (Stephens) (Coleoptera: Cucujidae), *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae), *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), and *Trogoderma granarium* (Herbst) (Coleoptera: Dermestidae), are concentrated in the center zone of bulk grain (Hagstrum et al., 1985; Sedlacek et al., 1998b). For distribution of parasitoids in grain mass, Press (1992) and Sedlacek et al. (1998a) recorded that most parasitoids were also found in the center of the grain mass, along with the hosts. To evaluate parasitoid efficiency, we must understand its host-location behavior. Information on host location by *A. calandrae* is still incomplete. Distribution of *A. calandrae* within stored grain would be one factor affecting host location. We examined the host location and distribution of *A. calandrae* using the silo model. Our study has implicaiotns for biological control of *A. calandrae*.

2. Materials and Methods

2.1. Insects

The larval solitary ectoparasitoid (*A. calandrae*) and the *S. zeamais* host were obtained from the Postharvest Technology Research and Development facility (Postharvest and Product Processing Research and Development Office, Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkhen, Bangkok.) Both insect species were collected and mass reared at 25°C under laboratory conditions at the National Biological Control Research Center (NBCRC), Kasetsart University, Bangkok, Thailand. *Sitophilus zeamais* was mass reared using brown rice as a host substrate. Ryoo and Cho (1992) reported that intrinsic rate of increase of the rice weevil was highest on brown rice. Mated female wasps of *A. calandrae* were provided 21 day-old *S. zeamais* larvae for parasitism and ovipositions.

2.2. Silo model

A silo model with four floors was designed (Fig. 1, 2). This model was a plastic box (15x7x 21.5 cm) divided into four chambers. A sieve was inserted between adjacent chambers to make a silo model into four floors. The height of first, second, third, and fourth (upper most) floors were 0, 5.5, 11.0, and 14.5 cm, respectively.

2.3. Distribution parasitoid

Uninfested brown rice (90 g) and infested brown rice (30 g) were placed on the sieve of each floor (Fig. 2). *Anisopteromalus calandrae* (50 pairs) were released at the top of a silo model with a hole on the top. The number of wasps was investigated on each floor after three days. This study was designed as four treatments and three replications each.

2.4. Statistical analysis

The number of wasps and their distribution were analysed using SPSS version 14.0.

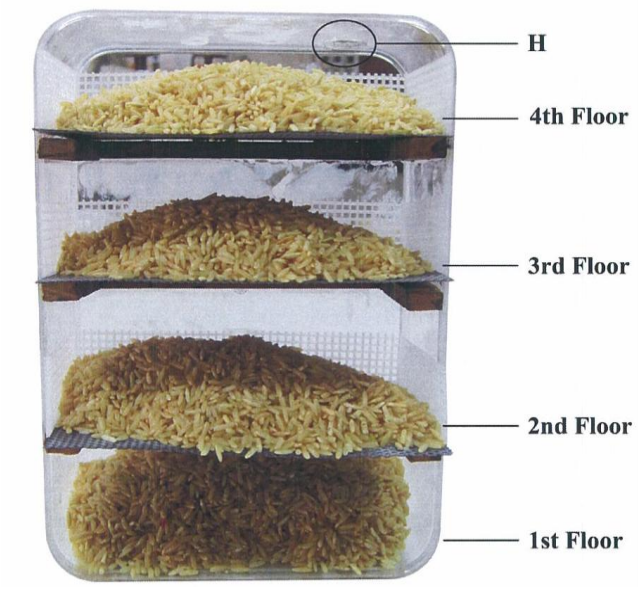

Figure 1 Silo model (front) with brown rice placed on each floor. H = Hole used to release the wasps.

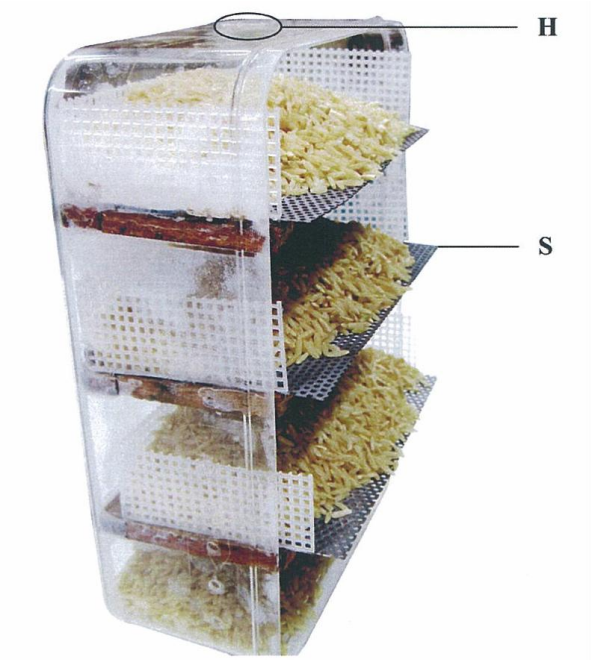

Figure 2 Silo model (side) with brown rice placed on each floor. H = Hole used to release the wasps, S = Sieve.

3. Results and Discussion

The most adults (192.33 ± 26.10) of *A. calandrae* were found at the fourth floor while the fewest wasps were at the bottom (the first floor) (Fig. 3). The numbers of *A. calandrae* present at the first, second and third floors were not significantly different (Table 1). The second, third and fourth floors showed no significant difference in number of wasps. The first

and fourth floors showed a statistically significant difference in number of wasps (Table 1). Adults of *S. zeamais* were found in the highest densities on the bottom floor (the first floor); adults of *A. calandrae* were found in the highest number on the top floor (the fourth floor) (Fig. 3 and Table 1).

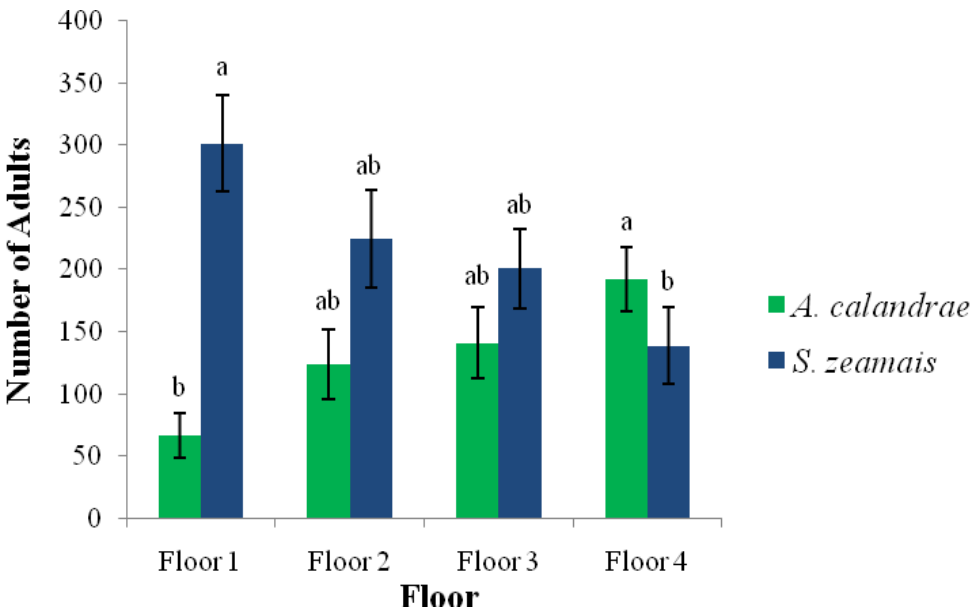

Figure 3 Number (Means±SE) of *Anisopteromalus calandrae* (Howard) and *Sitophilus zeamais* Motschulsky adults found on each floor.

Table 1 Number (Means±SE) of *Anisopteromalus calandrae* (Howard) and maize weevil, *Sitophilus zeamais* Motschulsky found on each floor.

Floor	*A. calandrae*	*S. zeamais*
1	66.33±17.95b	301.56±38.9a
2	123.55±27.90ab	225.0±39.4ab
3	141.00±28.60ab	200.78±31.7ab
4	192.33±26.10a	138.67±30.8b
F-tests	*	*
CV%	65.90	57.21

*Singnificant different at level of confident 95% (P value<0.05) Means followed by the same letter in a column are significantly different at 95% level of confidence (Duncan's New Multiple Range Test.)

4. Conclusions

Based on our study on the distribution of *A. calandrae* in a silo model, this wasp species was most abundant at the upper most level. *Anisopteromalus calandrae* female wasps parasitized all of *S. zeamais* larvae, and then they moved to lay their eggs at the lower floors

consecutively. This means *A. calandrae* could distribute over the silo model wherever its hosts were present. Our results support the study of Press (1992) which reported that *A. calandrae* exerted some degree of control over *S. zeamais* situated to a depth of 1.9 m in a column of wheat. In contrast, Press (1988) reported that *A. calandrae* did not readily move downward to parasitize *S. zeamais* host confined to the bottom of 2.2 m column of wheat. To study the host location in the silo, Steidle et al. (2003) and Steidle and Schöller (2002) released the larval parasitoid, *Lariophagus distinguendus* Förster (Hymenoptera: Pteromalidae) at the top of silo in their experiment. The results showed that *L. distinguendus* were 2-4 m deep while hosts were 4 m deep.

Parasitoids which were recorded on shelled corn (*Zea mays* L.) (Poaceae) in metal grain storage bins were *A. calandrae* (the most abundant), *Pteromalus* sp. *Cephalonomia tarsalis* (Ashmead) (Hymenoptera: Bethylidae), *Cephalonomia* spp. (Hymenoptera: Bethylidae), *Habrobracon hebetor* Say ((Hymenoptera: Braconidae), *Theocolax elegans* (Westwood) (Hymenoptera: Pteromalidae) and unidentified parasitoid of the family Eurytomidae (Sedlacek, et al., 1998a). Sedlacek, et al. (1998a) reported that *A. calandrae* and *Pteromalus* sp. were found in the great number in the center of the grain storage bins. But we found *A. calandrae* mostly on the top of silo model in the experiment while *S. zeamais* was found in the most density on the bottom floor (the first floor) (Fig. 3 and Table 1). Since *A. calandrae* were found on the top of bulk grain more than other levels while *S. zeamais* located mostly on the bottom so our result suggested that the release site of *A. calandrae* should be the most infestrations. Based on our study, *A. calandrae* would move upward and then it would be able to suppress *S. zeamais* population over grain mass.

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