NOTE

Comparative Penetration Efficacy in Wheat Between the Weevil Parasitoids *Anisopteromalus calandrae* and *Choetospila elegans* (Hymenoptera: Pteromalidae)[1]

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The rice weevil, *Sitophilus oryzae* (L.), is one of the most damaging cosmopolitan pests of stored grains, such as wheat, corn and rice. Some of the major Pteromalid parasitoids of *S. oryzae* are *Anisopteromalus calandrae* (Howard), *Choetospila elegans* Westwood, *Dibrachys cavus* (Walker) and *Lariophagus distinguendus* (Foerster) (Sinha, R. N. and F. L. Watters, Agriculture Canada, 290 pp. 1985). *Anisopteromalus calandrae* and *C. elegans* are distributed worldwide and are common ectoparasitoids of the larvae and pupae of many coleopterous insects associated with stored foods (Ghani, M. A. and H. L. Sweetman, Biologia (Lahore) 1: 115-139, 1955) (Krombein, K. V., P. D. Hurd, D. R. Smith and B. D. Burks. 1979. Catalog of Hymenoptera in America north of Mexico. Smithsonian Inst. Press 2735 pp.).

Laboratory tests have shown that *A. calandrae* has potential for suppressing *S. oryzae* in wheat (Cline, L. D., J. W. Press, and B. R. Flaherty, J. Econ. Entomol. 78: 835-838, 1985) (Press, J. W., L. D. Cline, and B. R. Flaherty, J. Ga. Entomol. Soc. 19: 110-113, 1984). *Choetospila elegans* and *A. calandrae* suppressed, the closely related *S. zeamaize* Motschulsky on corn under laboratory and field conditions (Williams, R. N. and E. H. Floyd, J. Econ. Entomol. 64: 1407-1408). For these reasons, *A. calandrae* and *C. elegans* were selected as our test insects.

Effective suppression of an *S. oryzae* population by *A. calandrae* or *C. elegans* depends primarily on the parasitoid's ability to locate its host within a grain mass. The most efficacious method to introduce parasitoids would be on the surface of the grain mass after the filling of the bins has been completed. Laboratory studies indicated, however, that *A. calandrae* did not readily move downward to parasitize *S. oryzae* hosts confined to the bottom of 2.2 m columns of wheat (Press, J. W., J. Agric. Entomol. 5: 205-8). Since *C. elegans* is considerably smaller than *A. calandrae* and, presumably better able to move between the wheat kernels, we decided to determine if *C. elegans* could penetrate to reach *S. oryzae* infested wheat more effectively than *A. calandrae*.

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Laboratory cultures of *S. oryzae* (23-d-old) reared on ca. 300 g of soft red winter wheat were used in this study. The cultures contained ca. 1600 *S. oryzae* larvae each. Three of these cultures were thoroughly mixed, then divided into three equal lots to ensure that a uniform number of larvae would be available for each test condition. The three infested lots were placed individually into wide mouth 0.95 *l* jars to a depth of ca. 7 cm. Uninfested wheat was added to completly fill the jars. Three 1. 9 m × 7.5 cm acrylic cylinders were fitted with jar rings at each end so that the 0.95 *l* jars containing the *S. oryzae* infested grain could be attached to them. The three cylinders were then filled with uninfested soft red winter wheat. The 0.95 *l* jars containing the *S. oryzae* infested grain were attached to the bottom of each cylinder. The jars containing uninfested grain were attached to the top of each cylinder to make a column of wheat ca. 2.2 m high when secured perpendicularly (Press, J. W., J. Agric. Entomol. 5: 205-8).

In the first sequence of tests, ten 24-h-old male and ten 24-h-old female *A. calandrae* were introduced into the top 2.5 cm of the first grain column through a 1.5 cm hole in the jar's side. The hole was sealed with a rubber stopper. Ten mated pairs of *C. elegans* were introducted into a second grain column as described previously. Males and females of the parasitoids were held together for 24-h prior to introduction to enhance the probability of mating. The third remained without parasitoids and served as the control. In a second sequence of tests, the same procedure was followed, with the exception that the infested wheat was contained at the top of the grain column. The bottom infestation sequence was replicated 10 times and the top infestation sequence was replicated six times. Infested grain was removed from each wheat column after 7 d, then incubated for 17 more d for *A. calandrae* and 24 more d for *C. elegans*. *C. elegans* was incubated longer because of its longer developmental period.

All tests were conducted at 27 ± 1° C and 60 ± 5% RH under an alternating 12L:12D cycle. Data were analyzed for significance using the students t-test and analysis of variance (ANOVA) procedures with the Duncan's multiple range test option to separate the means ($P > 0.05$) (SAS Institute. 1987).

When infested wheat was located at the surface of the column, suppression of *S. oryzae* was 55.1% and 69.2% with *A. calandrae* and *C. elegans,* respectively ($P > 0.05$ Table 1). However, *C. elegans* caused much higher suppression (58.3%) of *S. oryzae* infesting wheat at the bottom of the column than did *A. calandrae* (17.7%). The number of F_1 *C. elegans* from *S. oryzae* infesting the bottom of the column was 995.3 ± 120 compared with 179.3 ± 41 F_1 *A. calandrae.* These differences were highly significant ($t = 6.52$ df 18, $P < 0.001$). The number of F_1 *C. elegans* produced from *S. oryzae* infestations at the top of the column did not differ significantly ($t = 0.54$, df 14, $P > 0.05$) from those produced from *S. oryzae* infestation occurring at the bottom of the column. However, F_1 *A. calandrae* progeny produced from *S. oryzae* infestations at the top of the wheat column were significantly greater ($t = 6.66$, df 14, $P < 0.001$) than the number of *A. calandrae* produced from the *S. oryzae* infestation occurring at the bottom of the column.

These data suggest that both *A. calandrae* and *C. elegans* would be equally effective against weevil populations occurring near the surface of a grain mass or possibly against weevils subsisting in residual grain debris in and around storages. However, because of *C. elegans* better downward penetration through wheat

Table 1. Mean (± SE) number of insects recovered from *Sitophilus oryzae* infested wheat located in the top (7 cm) or bottom (7 cm) of 2.2 m columns of wheat in which 10 pr of the weevil parasitoids *Anisopteromalus calandrae* or *Choetosphila elegans* had been released for 7 d. †‡

Area of column infested by *S. oryzae*	Column 1 with *C. elegans*		Column 2 with *A. calandrae*		Column 3 control
	S. oryzae	*C. elegans*	*S. oryzae*	*A. calandrae*	*S. oryza*
Top*	539.7 ± 138.9 c	1101.0 ± 109.3	788.7 ± 139.6 c	862.7 ± 113.3	1754.7 ± 291.1 a
Bottom**	646.8 ± 77.6 c	995.3 ± 120.0	1276.5 ± 91.6 b	179.3 ± 41.0	1550.6 ± 66.4 a

† All means (rows and columns) for *S. oryzae* not followed by the same letter were significantly different ($P = 0.05$ level, Duncan's NMRT).

‡ Parasitoids were introduced into the top of the columns.

* 6 replicates

** 10 replicates

and its subsequent higher level of weevil parasitization well beneath the surface, it would be the parasitoid of choice for release to suppress weevil infestations in bulk grain where many infested kernels are likely to occur deep within a grain mass.

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