

**Scientific Note****COMPETITION BETWEEN *ANISOPTEROMALUS CALANDRAE* (HOWARD) AND *CHOETOSPILA ELEGANS* WESTWOOD (HYMENOPTERA: PTEROMALIDAE) AT DIFFERENT PARASITOID DENSITIES ON IMMATURE RICE WEEVIL *SITOPHILUS ORYZAE* (L.) (COLEOPTERA: CURCULIONIDAE) IN WHEAT**M M RAHMAN<sup>1</sup> & W ISLAM\*

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Density dependent competition between parasitoids was studied by exposing immature rice weevils, *Sitophilus oryzae* (L.), developing in wheat to *Anisopteromalus calandrae* (Howard) alone, *Choetospila elegans* Westwood alone, or both species together. With *A. calandrae* only, the emergence of *A. calandrae* progeny tended to peak near four or eight female parasitoids and parasitoid-induced mortality increased with increasing parasitoid numbers. With *C. elegans* only, parasitoid emergence increased, but parasitoid-induced mortality did not change with an increase in numbers of parasitoids. *A. calandrae* in combination with *C. elegans* produced similar reductions in rice weevil populations, as did *A. calandrae* alone. *C. elegans* alone was less efficient than *A. calandrae* alone at low parasitoid densities, but when numbers of *C. elegans* reached higher densities, rice weevil mortality was as great as that with *A. calandrae* alone. Under competitive conditions, the sex ratio (female percentage) of *C. elegans* was decreased by the presence of *A. calandrae*, but the sex ratio of *A. calandrae* was not affected by *C. elegans*. Competition reduced emergence of both *A. calandrae* and *C. elegans*; however, *A. calandrae* was clearly the dominant species when rice weevils were exposed to equal numbers of both species of parasitoids.

**Keywords:** *Anisopteromalus calandrae*, *Choetospila elegans*, *Sitophilus oryzae*, stored wheat.

Biological control is generally considered as a promising alternative to insecticidal control of insect pests. Two promising biological control agents against *Sitophilus oryzae* (L.) are the pteromalid wasps, *Anisopteromalus calandrae* (Howard) and *Choetospila elegans* Westwood. Interspecific competition among natural enemies of a given host can be of great importance in the application of control (van Alebeek *et al.* 1993). Competition among species of insect parasitoids

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or predators can influence the size and structure as well as the stability of insect communities (Mackauer 1990). It is possible that interspecific competition among parasitoids could lead to reduced levels of overall parasitization and pest population regulation (Ehler and Hall 1982). However, coevolved parasitoids could minimize competition by niche differentiation or interspecific host discrimination and produce greater suppressive effects (van Alebeek *et al.* 1993).

Two hymenopteran parasitoids in the family Pteromalidae, *A. calandrae* and *C. elegans*, are solitary ectoparasitoids. Both *A. calandrae* and *C. elegans* attack immature stages of several insect pests of stored products. Laboratory studies have shown the potential for suppressing populations of the rice weevil, *Sitophilus oryzae* (L.) in wheat by *A. calandrae* and by *C. elegans* (Press 1992). Both *A. calandrae* and *C. elegans* can affect populations of the maize weevil, *S. zeamais* Motschulsky, in corn (Arbogast and Mullen 1990). Several studies have been conducted on the bionomics of *A. calandrae* (Smith 1992) and *C. elegans* (Almeida and Matioli 1984).

The purpose of this study was to investigate the competition between *A. calandrae* and *C. elegans* in stored wheat to determine whether these two parasitoids can coexist better in wheat and to assess the implications of this information for augmentative release of these parasitoids. The rice weevil, *S. oryzae*, was chosen in this study because in wheat the rice weevil is the more serious pest insect (Longstaff 1981).

Three thousand of *S. oryzae* adults were taken from stock culture maintained in control temperature room ( $30\pm 0.5^{\circ}\text{C}$  and 70% and added to 3 kg of uninfested wheat). The uninfested seeds had been disinfested by heat, shifted over a #10 sieve to remove dockage, and equilibrated to room temperature. Twenty-four hours later, adult *S. oryzae* removed. After 18 days of infestation, the seeds were mixed thoroughly, weighed into 200 g samples, and placed in different jars (500 ml). The adult mated female parasitoids (0-24 h old) were added to each in three combinations; *A. calandrae* alone, *C. elegans* alone and both species combined. Five densities of parasitoids (2, 4, 8, 16, and 32 pairs) were used. In the combinations treatments, half of the parasitoids pairs were comprised of each species. Infested seeds were exposed to the parasitoids for 3 days to minimize host development, and the parasitoids were then removed. Five jars of infested wheat without parasitoids served as control. All treatments were replicated five times.

At the emergence time of  $F_1$  parasitoids, the seeds were transfer once every 2 days to remove adult parasitoids, which were identified and counted. The total rice weevil mortality was estimated by subtracting the number of rice weevils emerged in the treatments from the average number of rice weevil emerged in the control. *S.*

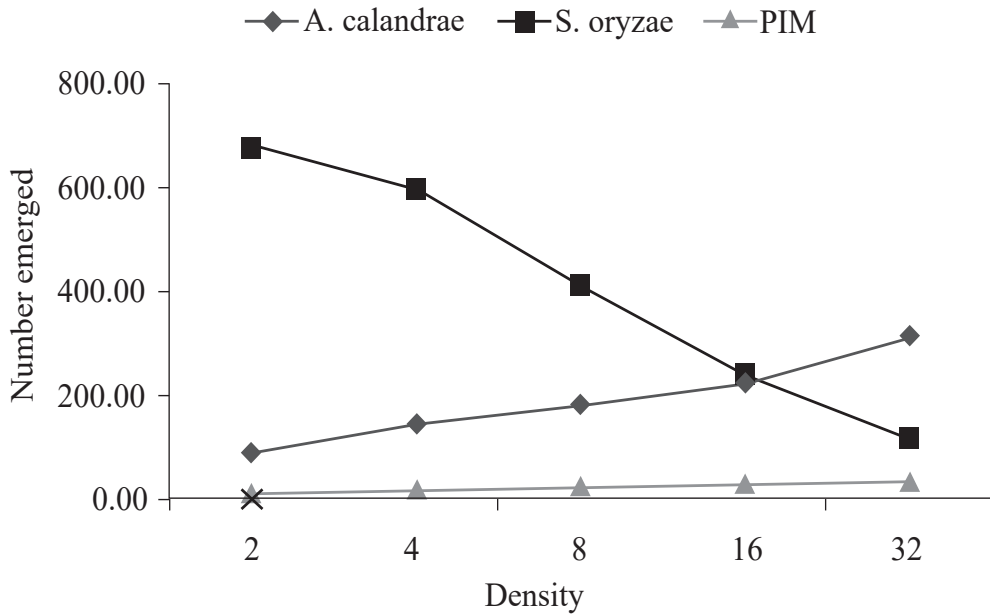
*oryzae* mortality consisted of the two components: rice weevils that produced F<sub>1</sub> adult parasitoids and rice weevils that died from some unknown cause called parasitoid induced mortality (PIM). Pawson *et al.* (1987) defined PIM as that proportions of hosts that failed to produce either an adult host or and an adult parasitoid. PIM incorporate many factors such as host feeding by parasitoids, parasitized hosts where no egg is laid and any parasitoid mortality during development. These factors are very difficult to separate with hidden hosts. The percent emerged of *S. oryzae* was calculated by dividing the number of F<sub>1</sub> adult emerged in each jar by average number of adult *S. oryzae* emerged in the controls. The percent emergence of parasitoid was then added and this value was subtracted from 100% to yield the percentage of weevils that died from PIM.

The hosts after 18 days of infested seeds by *S. oryzae* were mixed thoroughly for the same treatment. Others techniques for culturing were similar. The parasitoid induced mortality (PIM) was calculated by using following formula:

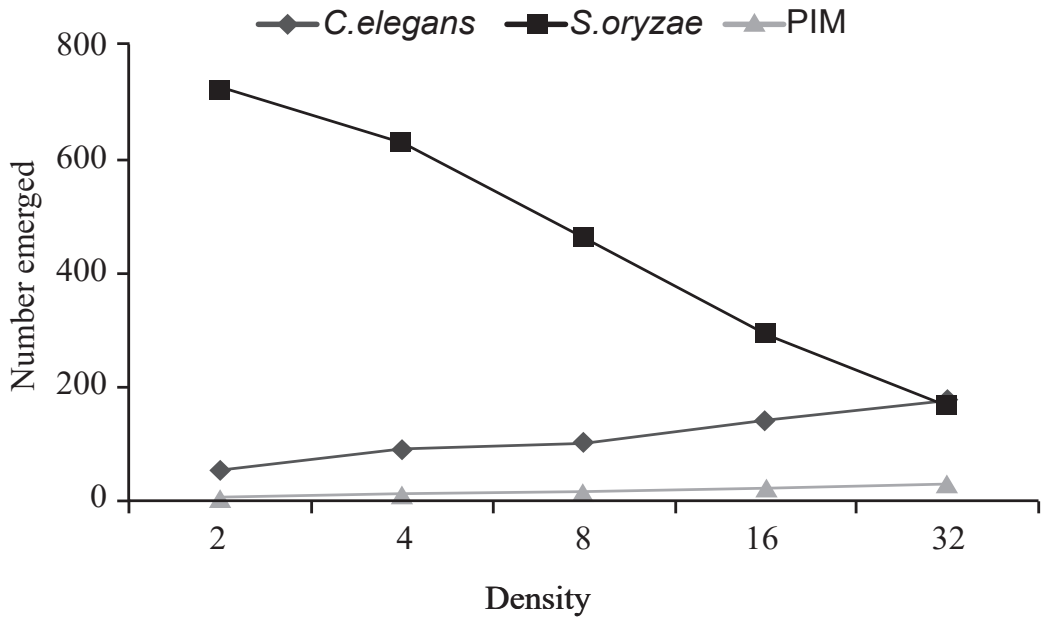
$$\text{PIM} = \frac{\text{The average number of rice weevils that emerged when no parasitoids were added} - \text{the number of all insects including parasitoids that emerged in each replicate}}{\text{The average number of rice weevils that emerged when no parasitoids were added.}}$$

For 2, 4, 8, 16 and 32 pairs of *A. calandrae* the number of *A. calandrae* ranged from 90.80±6.22 to 314.40±4.22 (Fig. 1). The maximum number of *A. calandrae* was emerged (314.4) at higher pair (32) of densities. There is significance difference between the emergence of *A. calandrae* and between different parasitoid densities (P<0.001, F=222.98). When *S. oryzae* infested wheat seeds were exposed to *A. calandrae*, only *S. oryzae* emergence at 2, 4, 8, 16 and 32 pairs density of parasitoids were 680.20±25.65, 599.20±23.50, 412.20±17.25, 242.40±13.69 and 116.80±9.63, respectively. Parasitoid Induced Mortality (PIM) were 11.71±2.3, 19.14±2.21, 25.71±3.57, 30.86±2.37 and 35.14±2.18, respectively (Fig. 1).

For the release of same respective pairs of *C. elegans*, the emergence of *C. elegans* were 56.20±4.09, 90.60±4.31, 103.80±4.46, 143.60±3.25 and 178.60±3.65 respectively (Fig. 2). The results indicated that at higher densities (16 and 32 pairs) the highest numbers (143.6 and 178.6) of *C. elegans* were emerged which is highly significant (P<0.001, F=142.57). In case of *C. elegans*, *S. oryzae* emergence at 2, 4, 8, 16 and 32 pairs density of parasitoids were 722.20±23.35, 629.60±20.75, 462.40±16.95, 296.60±14.55 and 168.40±7.88 respectively. Parasitoid Induced Mortality (PIM) was 7.14±1.62, 11.71±0.53, 17.43±2.04, 23.14±0.81 and 28.86±2.56 respectively which are shown in Fig. 2.



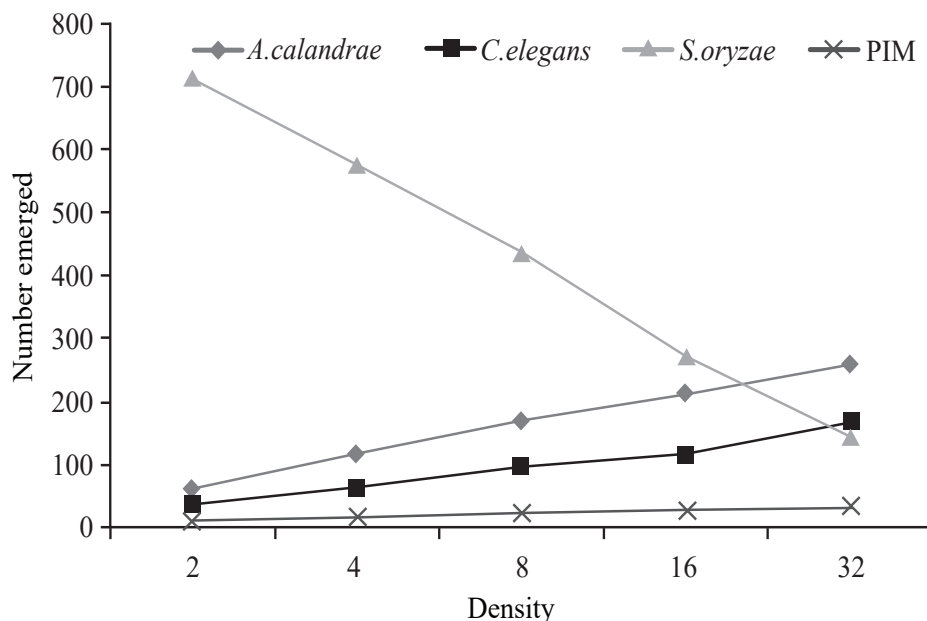
**Fig. 1.** Emergence of *A. calandrae*, *S. oryzae* and PIM at different densities in 200 g infested wheat by *S. oryzae*



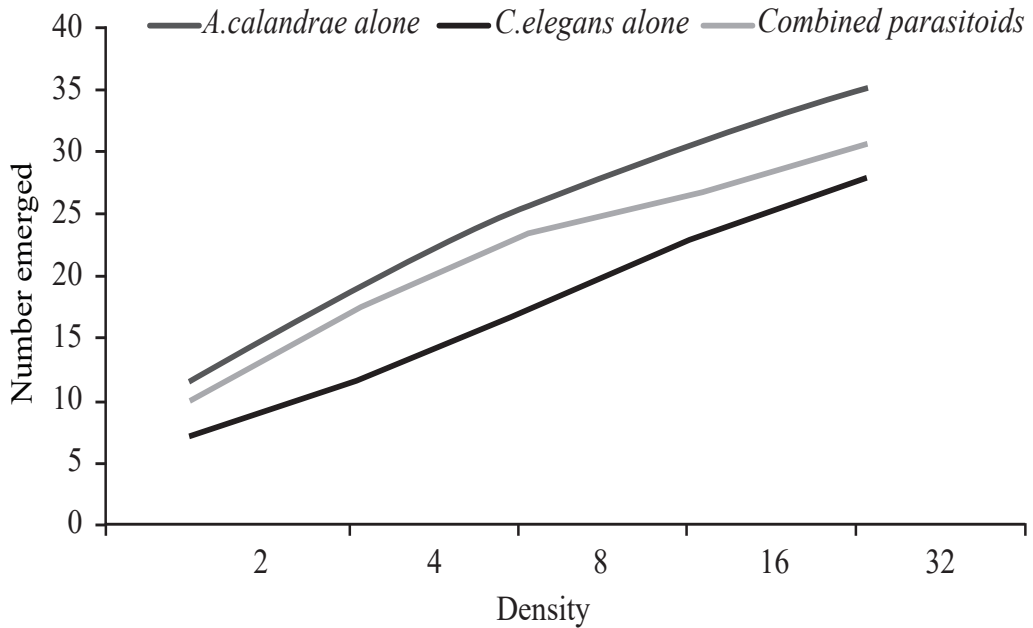
**Fig. 2.** Emergence of *C. elegans*, *S. oryzae* and PIM at different densities in 200 g infested wheat by *S. oryzae*

For combined release of the parasitoids, *A. calandrae* and *C. elegans*, emergence of parasitoids were  $60.80 \pm 2.37$ ,  $116.40 \pm 4.11$ ,  $170.60 \pm 3.61$ ,  $214.40 \pm 5.87$ ,  $260.40 \pm 6.84$ , and  $36.60 \pm 3.84$ ,  $62.80 \pm 3.92$ ,  $97.40 \pm 3.75$ ,  $116.60 \pm 4.69$ ,  $169.40 \pm 4.45$  respectively at different densities (2, 4, 8, 16 and 32 pairs) (Fig. 3). There is significant difference between the emergence of *A. calandrae* and *C. elegans* and between different parasitoid densities ( $P < 0.001$ ,  $F=264.91$  and  $F=156.18$ ).

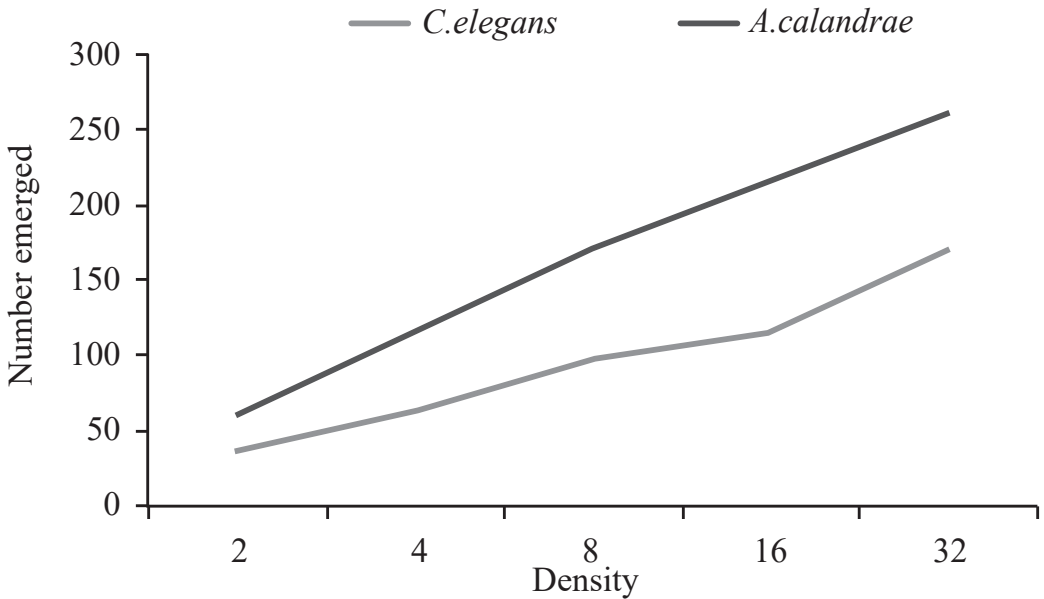
The emergence of rice weevil were  $714.80 \pm 21.65$ ,  $576.00 \pm 18.50$ ,  $436 \pm 16.23$ ,  $271.60 \pm 13.45$ ,  $144.20 \pm 7.78$  and PIM were  $9.86 \pm 1.81$ ,  $17.43 \pm 2.21$ ,  $23.43 \pm 0.92$ ,  $26.71 \pm 3.75$ ,  $32.57 \pm 2.95$  respectively. The emergence of *A. calandrae*, *C. elegans*, *S. oryzae* and PIM showed combined in Figure 3. Figure 4 showed the emergence PIM at different densities (2, 4, 8, 16 and 32 pairs) of the parasitoids *A. calandrae* alone, *C. elegans* alone and combined treatment. The results obviously trend of *S. oryzae* mortality increasing as the number of suppressing insects increased was observed with each natural enemy or their combination. Significant difference ( $P < 0.001$ ) in the number of parasitoids emerged (*A. calandrae* alone, *C. elegans* alone and both parasitoids combined) was for the competition and parasitoid density. Figure 5 shows emergence of *A. calandrae* and *C. elegans* at different treatment (*A. calandrae* and *C. elegans*).



**Fig. 3.** Emergence of *A. calandrae*, *C. elegans*, *S. oryzae* and PIM at different densities in 200 g infested wheat by *S. oryzae*



**Fig. 4.** Emergence of PIM at *A. calandrae* alone, *C. elegans* alone and combined treatment at different densities in 200 g infested wheat by *S. oryzae*



**Fig. 5.** Emergence *A. calandrae* and *C. elegans* at different treatment at different densities in 200 g infested wheat by *S. oryzae*

There is also significant difference ( $P < 0.001$ ) between different parasitoid densities of *A. calandrae* and *C. elegans* and their combined treatment on Parasitoid Induced Mortality (PIM).

The present study showed that emergence of the weevils, parasitoids and PIM at different densities were not uniformly distributed for the parasitoids, *A. calandrae* and *C. elegans* released alone and combined to the host, *S. oryzae* that were alone and combined. Suppression for each level of parasitoids was significantly different from all other levels. Thus, the obvious trend of *S. oryzae* mortality increasing the number of suppressing insects increased was observed with *A. calandrae* and *C. elegans* alone and combined. The percentage of host emergence decreased with the increasing density of *A. calandrae* and *C. elegans* which is similar to the result of Wen *et al.* 1994. The number of *A. calandrae* that emerged differed significantly comparing to *C. elegans*. The emergence of *A. calandrae* was higher than that of *C. elegans*.

When rice weevil was exposed to the equal numbers of both parasitoids, the overall emergence of *A. calandrae* was twice that of *C. elegans*. This indicated that *A. calandrae* was dominant species when the host was exposed to equal numbers of both the species. Similar results was found in case of *Eupelmus vuilleti* (Crawfood) and *Dinarmus basalis* (Rond.) ectoparasitoids of immature stages of Bruchidae where *E. vuilleti* was dominant over *D. basalis* (van Alebeek 1991).

Significant difference was in the number of hosts killed but did not produce a parasitoid (PIM) when either parasitoid species was alone or both were present. Not only that but also parasitoid density had the significant effect on the Parasitoid Induced Mortality (PIM). By increasing parasitoid density resulted increasing PIM. *C. elegans* that tended to produce the number of PIM and *A. calandrae* produced the maximum PIM and the combination of the parasitoids produced an intermediate PIM. This finding was similar with that of Wen *et al.* 1994. It was not possible to determine from this experiments what proportion of the PIM caused by host feeding, superparasitism, or unsuccessful parasitism. A high level of PIM, though, caused by higher densities of parasitoids involving direct death of hosts, production of  $F_1$  parasitoids might be more beneficial in biological control programme. Thus, the greater production of parasitoids in the combination release should be benefit. However, this advantage must be balanced against the relatively poor performance of *C. elegans* against *S. oryzae* in wheat and the greater expense and complexity of rearing and releasing two agents instead of just one.

The host mortality did not differ when *A. calandrae* was used alone or when the combination of parasitoids were used; both mortalities were significantly higher when *A. calandrae* were used alone. This indicates that the combination of *A. calandrae* and *C. elegans* produced the same suppressive effects as *A. calandrae* alone when the total number of parasitoids was equal.

The effect of sex ratio could be explained by several mechanisms: (1) host size discrimination is strong, interactions among adults could cause *C. elegans* to oviposit on smaller hosts (Shimada and Fujii 1985a, 1985b), on which they would tend to oviposit more eggs that might produce male (van den Assem *et al.* 1984, Yoo and Ryoo 1989); (2) the cause of weak host size discrimination, larval competition could be cause the destruction of *C. elegans* in host size preferred by *A. calandrae* (Smith 1993a, 1993b), leaving survivors only in smaller host which would tend to have more males; (3) adult interactions could favour the depositions of relatively more male eggs, according to local mate competitions theory (Werren 1984, King 1989). However, this would not explain why a greater density dependent effect caused by inter specific competition; and (4) the insemination and the efficiency of mate-finding could also affect sex ratio (Hawkes 1992) because of virgin females produce only male offspring.

This is indicated that the two parasitoid species parasitize the same stages of the host and, therefore, they might complete for host resources by niche displacement when both were present. They act independently and are not antagonistic.

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