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# Occurrence and preference of *Anagrus incarnatus* Haliday (Hymenoptera: Mymaridae) on eggs of two rice planthoppers in Taiwan

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## ABSTRACTS

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Field surveys were conducted in several sites to study occurrence of *Anagrus incarnatus* Haliday and its parasitism on eggs of rice brown planthopper (BPH). *A. incarnatus* population increased with the increment of BPH at first and second cropping seasons. It peaked during the ripening stage of rice plants at about 46% parasitism at Si-chou in both cropping seasons. The host preference of *A. incarnatus* to eggs of *Nilaparvata lugens* Stål (BPH) and small brown planthopper, *Laodelphax striatellus* (Fallen) (SBPH) was determined in the laboratory by free- and no-choice tests. The parasitoid preferred BPH to SBPH eggs in a free choice test. More *A. incarnatus* foraged on rice plants infested with BPH eggs than those infested with SBPH eggs, and more *A. incarnatus* progeny emerged from BPH than from SBPH eggs. The relationship between BPH infesting densities and the emergent *A. incarnatus* is linear regardless if rice variety is susceptible or resistant to BPH. The impact of the parasitoid on rice planthoppers is discussed.

(Key words: Rice, planthoppers, egg parasitoid, preference, *Anagrus*)

## INTRODUCTION

The rice brown planthopper (BPH), *Nilaparvata lugens* Stål, and small

brown planthopper (SBPH), *Laodelphax striatellus* (Fallen), are currently the most important insect pests of rice in Taiwan (Chiu, 1979; Miura *et al.*, 1981). Both species cause damage to rice plants by direct feeding and by transmitting virus diseases. BPH feeds around the basal parts of rice plants while SBPH prefers to feed in the upper portions. SBPH used to be a minor pest but it is gradually gaining economic importance in Taiwan. Their control is based on insecticidal sprays.

There are about 18 identified parasitoid species attacking the two hoppers in Taiwan (Chiu, 1979). In past decades, their efficacy was limited due to overuse of insecticides. However, because of low rice price, short of labour, and the public's concern about environment, the frequency of insecticidal application has been reduced and consequently promoted parasitoid activities. Therefore, their role in keeping the hoppers under check should not be overlooked.

Among these parasitoids, the recently recorded *Anagrus incarnatus* Haliday (Hymenoptera: Mymaridae) is one of three *Anagrus* species identified in Taiwan (Chen & Yu, 1989). It had been also recorded from several other Asian countries (Sahad & Hirashima, 1984; Watanabe *et al.*, 1992). *A. flaveolus* Waterhouse and *A. optabilis* (Perkins) are the two species previously recorded attacking rice planthoppers in Taiwan (Miura *et al.*, 1981; Sahad and Hirashima, 1984). *A. optabilis* was the dominant parasitoid species recovered from eggs of BPH, SBPH, and whiteback planthopper, *Sogatella furcifera* (Horvath) (WBPH) collected at 25 different locations with varied levels of parasitism (Miura *et al.*, 1981). The three *Anagrus* species can be easily identified according to their antennal characters (Sahad & Hirashima, 1984). No data about parasitism levels were available from Wu-feng, Tsu-shan, Ming-hsuing, and Si-chou where planthopper eggs were not found as reported earlier by Miura *et al.* who made the survey throughout the island (Miura *et al.* 1981).

Nothing is known about the occurrence of *A. incarnatus*, and its interrelationships with BPH and SBPH in Taiwan. Chantarasa-ard *et al.* (1984a) reported that the parasitoid did not show any host preference in Japan. However, this conclusion was based on percent parasitism without taking into account of unemergent parasitoids. Moreover, the population fluctuation of BPH and SBPH in Taiwan indicated that *A. incarnatus* might be one of the factors regulating them. Also, as BPH and SBPH infest different parts of the rice plant, the searching behaviour of *A. incarnatus* is of interest. Other egg parasitoids such as three species of *Trichogramma* showed habitat preference which affected the amount of parasitism and the dominance within respective favorable habitat (Flanders, 1937). Effect of the different habitats of BPH and SBPH on the parasitism level of *A. incarnatus* is not yet known.

The objectives of this study were

to determine the abundance and parasitism rates of *A. incarnatus* on its various hosts in the field, the relationships between the densities of its hosts and itself, and its host preference.

## MATERIALS AND METHODS

Field surveys were conducted in 1990 for rice planthoppers and their egg parasitoids during the two crop seasons at Wu-feng (Taichung county), Tsu-shan (Nantou county), Si-chou (Changhua county), and Ming-hsuing (Chia-I county), Taiwan. From the 20th day after transplanting, the rice seedlings and onwards 100 tillers of rice plants were randomly collected weekly from a paddy field at each location. Samples collected were separated, marked, and put in 2 × 18 cm test tubes covered with cotton wool to prevent the emergent parasitoids from escaping. A week later, the parasitoids were mounted on slides and identified. The number of parasitoid species was recorded for each sampling date and location.

The effect of exposing BPH eggs to *A. incarnatus* at various densities was determined in the laboratory. The experiment was designed by infesting rice plants five BPH infestation densities (1, 2, 3, 4 & 5 mated females) for one day, then, exposing the infested rice plants to 1, 3 & 6 mated females of *A. incarnatus* at 10 replicates. Taichung Native No. 1 (TN 1) and Tainung 67 rice cultivars were used in the experiment. TN 1 is susceptible whereas Tainung 67 is moderately resistant to BPH and SBPH. At 30 days after planting, rice plants were thinned to five plants per pot (1/5,000 a). The pots were then infested with BPH and exposed to *A. incarnatus*. Pots were covered with a transparent plastic cylinder (16 × 60 cm, dia. × height) to prevent the insects from escaping. Parasitoids were removed two days later, and the pots were kept in growth chamber at 25 ℃ and a photoperiod of 12:12 (L:D) h. A week later, number of BPH nymphs hatched and adult *A. incarnatus* emerged were counted and recorded daily for each treatment. When all insect emergence ceased, all rice plants and BPH eggs were dissected to determine the number of unemerged parasitoids. The data were analyzed using ANOVA and Duncan's New Multiple Range Test at 5% significance level (SAS Institute, 1982).

The preference of *A. incarnatus* for planthopper eggs was determined by laboratory free-choice and no-choice experiments. Free-choice test was conducted by dividing potted (12 cm in diameter) rice plants into two portions, each covered with a small plastic cylinder cage (4 × 12 cm, dia. × height). Then, two mated BPH or SBPH females were separately introduced into the cage. One day after, the hoppers and the small cage were removed and replaced by a bigger cage (10 × 18 cm, dia. × height) which covered the whole pot. Five newly emerged and mated *A. incarnatus* females were then introduced to the rice plants. The experiment was replicated 10 times and conducted

at 25 ℃ and 12:12 (L:D) h in a growth chamber. The number of parasitoids attacking eggs of either host species was recorded every 2 hours consecutively for the first 12 hours and then daily for another three days. Data were analyzed using ANOVA and means separation using *t* test at 0.05 significant level.

The no-choice experiment was conducted by infesting rice plants in separate pots with BPH or SBPH adult females for two days. Five newly emerged and mated *A. incarnatus* adult females were introduced into each pot containing either BPH or SBPH eggs. The pots were soon covered with plastic cages to prevent parasitoids from escaping. Two days later, the wasps were removed and the pots were kept in growth chamber under 25 ℃ and 12:12 (L:D) h. Young nymphs hatching from unparasitized planthopper eggs and emerging parasitoids were recorded, and removed daily. When emergence of parasitoids ceased, the rice plants and unemerged parasitoid eggs were dissected and recorded to obtain an accurate figure for parasitism for the two plant-hoppers. Data were analyzed using ANOVA and *t* test.

## RESULTS AND DISCUSSION

Parasitism rates on eggs of planthoppers by *A. incarnatus* were not found for the first three times of sampling but increased sharply after rice plants reaching the ripening stage for the first crop season at all study sites (Fig. 1). Planthoppers usually occur at

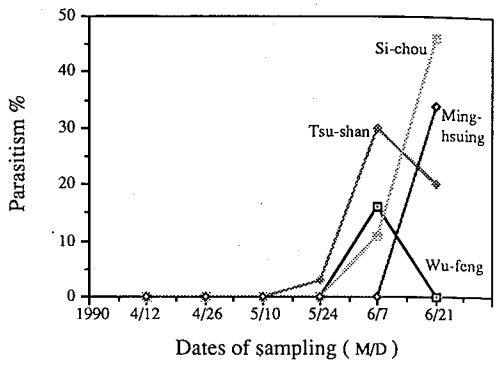


Fig. 1. Percent parasitism of BPH eggs by *A. incarnatus* at different localities during the 1st cropping season of 1990.

very low level before the ripening stage of rice plants in the first season. Its population as well as parasitism peaked during the ripening and the harvest stages of rice plant. The highest and the lowest parasitism rate of 46 and 0 % was recorded at Si-chou and Wu-feng respectively on June 21 of 1990 about one week before harvesting (Fig. 1). The percent parasitism of *A. incarnatus* on eggs of planthoppers at each sampling site in the second season was illustrated in Fig. 2. Parasitism levels peaked after the milky stage of rice plants except one during late tillering stage on August 30 of 1990 at Wu-feng. The higher parasitism rate at earlier growth stage was due to very low level of planthopper occurrence therefore increasing percent parasitism. The highest and the lowest parasitism rate of 47 and 8% was recorded at Si-chou and Wu-feng respectively on November 8 of 1990 nearly two weeks before harvesting (Fig. 2). Occurrence of planthoppers as well as egg parasitoid varied with different localities. A total of

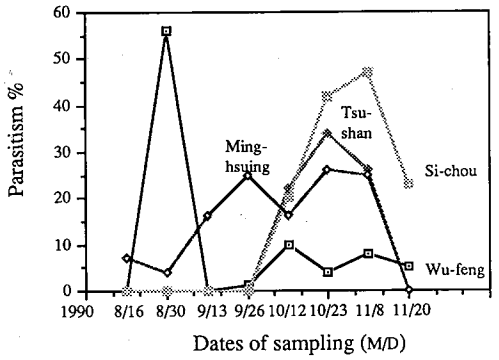


Fig. 2. Percent parasitism of BPH eggs by *A. incarnatus* at different localities during the 2nd cropping season of 1990.

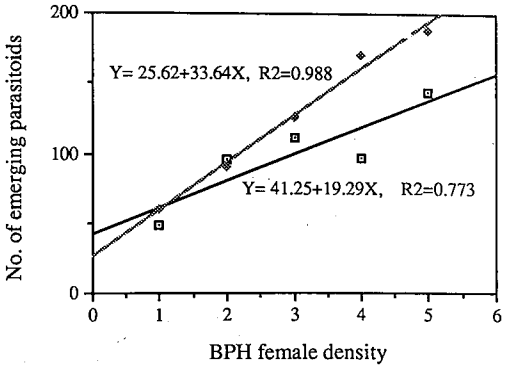


Fig. 3. Relationship between densities of infesting BPH females and number of *A. incarnatus* emerging from eggs deposited by the planthoppers on TN 1 rice cultivar.

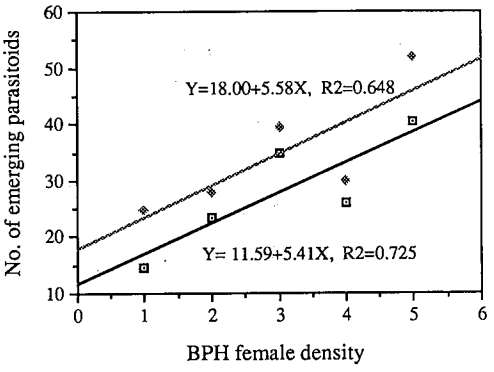


Fig. 4. Relationship between densities of infesting BPH females and number of *A. incarnatus* emerging from eggs deposited by the planthoppers on TNG 67 rice cultivar.

1,688 planthopper eggs parasitized by *A. incarnatus* were collected at Ming-hsuing, whereas only 37 parasitized eggs were obtained at Wu-feng. Results indicated that *A. incarnatus* was the only species of planthopper egg parasitoid found in this study which is the first report on a field population survey for this parasitoid. The other two species, *A. flaveolus* and *A. optabilis* which were previously reported by Miura *et al.* (1981), were not recovered from all the four sampling sites in this study.

The relationship between densities of infesting BPH females and the number of *A. incarnatus* emerging from host eggs was linear regardless if the rice cultivar was resistant or susceptible to BPH (Figs. 3&4). The total number of emerging parasitoids rose when the number of infesting BPH females or the number of searching *A. incarnatus* increased (Figs. 3&4). Similarly, Chantarasa-ard *et al.* (1984b) reported that *A. incarnatus* attacked more number of host eggs as their density increased and concluded that it fitted the Holling's (Type II) functional response. Griffith and Holling (1969) suggested that mutual interference is common in laboratory experiments. Although not measured in the current study, it is possible that mutual interference played a role. Hassell and May (1973) stated that the mutual interference should not be

overlooked under field conditions because parasitoid densities in the field could be higher than in the laboratory sometimes.

*A. incarnatus* female-biased progeny emerged from parasitized BPH eggs on both rice cultivars at all treatment combinations; sex ratio values were over 45 which is the value of 1:1 ratio after arcsine transformation (Table 1). Inconsistently more female progeny emerged when high densities of BPH were exposed to low densities of parasitoids. This observation corroborates the findings reported by Chantarasa-ard *et al.* (1984b) that the sex ratio of *A. incarnatus* is constant and unaffected by its own density or by the density of its host. The reproductive strategy of *A. incarnatus* therefore coincides with the model of Mackauer (1976) by which arrhenotokous parasitoids prefer to have some male progeny to guarantee reproduction.

The free choice host preference test revealed that *A. incarnatus* preferred BPH on SBPH eggs (Table 2). Within the first twelve hours of the experiment, significantly more parasitoids were found searching rice plants infested with BPH eggs than plants infested with SBPH ($t$ test, df=6, $p<0.01$). The number of parasitoids searching infested rice plants declined gradually within first 12 hrs after exposure. This might be an indication that the parasitoid utilized all host eggs within the first few hours after exposure and then gradually reduced its activity. In the free choice test, more BPH (53.0) than SBPH (11.3) eggs ($t$ test, df=6, $p<0.01$) were parasitized with 84.1 and 67.7% parasitism rate respectively. Similarly, results obtained from the no-choice test also showed that significantly more *A. incarnatus* emerged from rice plants infested with BPH eggs (29.9) than from plants infested with SBPH eggs (8.0) ($t$ test, df=10, $p<0.01$) and 66.7 vs. 28.5% parasitism respectively ($t$ test, df=10, $p<0.01$).

*A. incarnatus* exhibited a stronger host preference to BPH than to SBPH in the free and no-choice experiments.

Table 1. Sex ratio of *A. incarnatus* that emerged from parasitized eggs deposited by different densities of BPH on TN 1 and TNG 67 rice cultivars

| BPH density infested | TN 1 | | | TNG 67 | | |
|---|---|---|---|---|---|---|
| | Parasitoid density | | | | | |
| | 1 | 3 | 6 | 1 | 3 | 6 |
| 1 | 62.0 ab | 53.4 a | 56.3 a | 67.7 a | 56.7 ab | 48.4 c |
| 2 | 57.0 b | 56.3 a | 51.3 a | 49.0 b | 55.8 ab | 60.0 ab |
| 3 | 66.4 a | 62.2 a | 59.3 a | 58.0 ab | 51.7 b | 58.9 ab |
| 4 | 63.8 ab | 57.0 a | 63.8 a | 61.2 ab | 61.8 a | 64.8 a |
| 5 | 61.3 ab | 64.3 a | 61.7 a | 72.5 a | 63.1 a | 54.0 bc |

Sex ratio values are transformed by arcsine transformation. Means in each column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test.

Table 2. Number of *A. incarnatus* females searching on rice plants infested with BPH or SBPH eggs at different hours after exposure in the free choic test

| Host eggs | No. of *A. incarnatus* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 24 | 48 | 72 (hrs) |
| BPH | 4.0* | 4.3* | 3.7* | 2.4* | 2.3* | 2.0* | 1.0 | 0.4 | 0.1 |
| SBPH | 0.7 | 0.7 | 0.4 | 0.3 | 0.1 | 0.4 | 0.1 | 0.0 | 0.0 |
| *t* value | 5.1 | 5.0 | 5.1 | 4.7 | 3.6 | 3.9 | 1.9 | 1.0 | 1.0 |

(* $p<0.01$, *t* test)

These results could explain the current population fluctuation relationship between BPH and SBPH in Taiwan where the later species is gradually increasing in occurrence (B. H. Chen, unpublished data). Possibly because the activity of this egg parasitoid is enhanced after fewer insecticidal spray in paddy fields and consequently increasing parasitism on BPH. However, Chantarasa-ard *et al.* (1984a) reported that *A. incarnatus* showed no particular preference to its three host species : BPH, SBPH, and WBPH. The reasons to the different conclusions might lie in the difference in the experimental design. In the current study, the parasitoids were observed immediately after release and consecutively for every two hours to quantify the host preference of *A. incarnatus*. Chantarasa-ard *et al.* (1984a) used in their experiments high parasitoid densities which probably caused competition for the preferred hosts, and forced *A. incarnatus* to parasitize other host eggs simultaneously. Therefore, an even parasitism on all three hosts was resulted. Moreover, they did not make observations immediately after release and did not dissect rice plants and unemerged host eggs to calculate the actual number of host eggs deposited and those parasitized.

This study suggests that *A. incarnatus* is an efficient egg parasitoid of BPH and SBPH especially the former species is more preferred. It showed good searching ability for BPH eggs with high parasitism rates. This egg parasitoid along with resistant rice cultivars could be used together in an integrated pest management programme for BPH in Taiwan.

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## 摘 要

陳炳輝 1993 *Anagrus incarnatus* 之發生及對二種稻蝨寄主卵之偏好性 植保會刊 35:267-275.（台灣省農業試驗所 應用動物系）

本試驗於本省中部地區調查卵寄生蜂 *Anagrus incarnatus* Haliday 之發生及對稻蝨之寄生率，結果顯示無論一、二期作，該蜂族群隨其寄主褐飛蝨密度之增加而上升，其寄生率之高峰在水稻成熟期，而以溪州之 46% 爲最高。室內以自由選擇與無選擇試驗進行測定該蜂對褐飛蝨與斑飛蝨卵之偏好性，結果顯示該蜂對褐飛蝨卵俱偏好性，較喜在產有褐飛蝨卵之稻株上找尋寄主產卵，而較少於產有斑飛蝨卵之稻株上尋找。無論水稻品種爲感蟲或較抗蟲者，該蜂羽化數與褐飛蝨接蟲密度呈直線關係。同時，自被寄生之褐飛蝨卵羽化之該蜂數，遠比自被寄生之斑飛蝨卵者爲多。該蜂乃本省稻蝨之有效卵蜂。