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Release of *Aprostocetus hagenowii* (Ratzeburg) (Hymenoptera: Eulophidae) adults for the control of *Periplaneta americana* (L.)

S.A. Shamim[1], W. Islam[1*] and K.A.M.S.H. Mondal[1]
[1] Institute of Biological Sciences, Rajshahi University, Rajshahi 6205, Bangladesh.

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ABSTRACT

***Aprostocetus* (*Tetrastichus*) *hagenowii* (Ratzeburg), an oothecal parasitoid of the American cockroach, *Periplaneta americana* (L.) was released into experimental cartons to determine its potential as a biological control agent. The parasitoids were released into experimental cartons during March-June and July-October periods. Approximately 600 adult parasitoids of mixed sex were released three times per week. Percent parasitism of viable oothecae were 85.93% in March-June and 91.63% in July-October periods after 7 weeks of release. After 8-11 weeks when F_1 generation of the parasitoid was emerging, the percent parasitism was 89.29% in March-June and 96.51% in July-October whereas after weeks 12-17, parasitism was 87.5 and 94.52% respectively. *A. hagenowii* also showed a male : female sex-ratio of 1.4:1 during both periods.**

Key wards: *Aprostocetus hagenowii*, biological control, cockroach, *Periplaneta americana*.

INTRODUCTION

Periplaneta americana (L.) is the most common species of cockroaches found among the household insects. It feeds on all types of food and also transmits diseases (Ebeling 1978). Several insecticides have been used in the control of cockroaches. But these chemicals do not bring about the desired control when cockroaches live in cracks and crevices. There are several natural enemies of cockroaches, which include insects, arachnids, nematodes and vertebrates (Roth and Willis 1960). The most important natural enemies of cockroaches appear to be hymenopteran oothecal parasitoids (Cameron 1955, 1957; Lebeck 1991) which are suitable for urban pest control because of their small size, gregarious nature, and high searching ability. Oothecal parasitoids have a wide distribution and have a high potential for controlling cockroach populations (Roth and Willis 1954; Piper *et al.* 1978; Kumarasinghe and Edirishinghe 1987).

No definite attempts have been made to determine the effectiveness of *A. hagenowii* in managing populations of *P. americana* except for those of Roth and Willis (1954), Amonkar *et al.* (1974) and Piper and Frankie (1978). The objective of this study was to evaluate the effectiveness of inundative releases of mass-produced *A. hagenowii* for biological control of *P. americana* population and also to determine whether releases of parasitoids continuously over a period of 6 weeks would establish their population for continued suppression of *P. americana*.

* Corresponding Author

MATERIALS AND METHODS

Eight large paper cartons were used to simulate natural environment for *P. americana*. The rearing cartons were housed in a room. Each carton of size 1.5 x 1 x 1 m had walls and floor lined with white papers. All cracks in the walls and floor were sealed. The entry door was lined with a muslin cloth to ensure air circulation.

In early March, 75 laboratory-reared cockroaches (50 adult females and adult males) were collected from the IPM Laboratory, Institute of Biological Sciences, University of Rajshahi, Bangladesh and were released into each carton. Fresh bread was continuously supplied to the cockroaches in a petri dish (10 cm diam) placed in the carton. Water was provided in moistened cotton wads in a petri dish (8.5 cm diam).

One week after the introduction of cockroaches into the cartons inundative releases of *A. hagenowii* was started. Two hundred adults of mixed sex (aged 0-1 days) were released three times per week (Sunday, Tuesday and Thursday) for five weeks into all four cartons. The remaining four cartons served as untreated controls. Of the 200 adults, 60% were females. The releases were continued until the F_1 progeny of the parasitoid began emerging from deposited oothecae.

During the 7th week all the oothecae in each carton were collected in plastic containers (250 ml) and were covered with muslin so that the emerging parasitoids would be able to disperse into the cartons. The containers with oothecae were placed

in each cage and labelled according to the collection. After providing a supply of food and water the doors of the carton were closed.

After a further 4 weeks, all the newly deposited oothecae were collected again. They were placed in plastic containers on the 7th week of study. The oothecae collected during week 7 from release and nonrelease (control) cartons were examined for parasitoid emergence. Fresh food and water were placed in each carton. The dead cockroaches and waste products were removed from all the cartons. The doors were closed thereafter.

The cartons were reopened after five-weeks (week 17) and all the oothecae were collected and placed in plastic containers for further development. The dead cockroaches were removed from the cartons. The remaining live cockroaches were trapped. Parasitoids emerging in plastic containers (week 11) were counted and sexed to determine total number and sex ratio of emerging wasps in each carton. The parasitoids emerging from oothecae of week 17 were collected and their sex ratio was also determined.

A sample of 10 parasitized oothecae was collected from release and nonrelease (control) cartons from March - June and July - October periods respectively. Oothecae were placed in plastic containers covered with muslin and held in the cages. After emergence, the total number of parasitoids and their sex-ratio was determined. To determine the statistical significance of both numbers and sex ratio of parasitoid between two experimental period Student t-test was used.

Data on percent parasitism of oothecae from release and nonrelease (control) cartons per time period were subjected to an Analysis of Variance and Duncun's multiple range test.

As there was no constant temperature and humidity control systems, both experiments were conducted for two periods, one in March - June and the other in July - October. The daily temperature and relative humidity conditions were recorded. Mean temperature and relative humidity values in March - June period were 31.97 ± 0.28°C (range: 28 - 38°C) and 72.21 ± 1.95% (range: 08 - 98%) whereas in July - October periods were 29.47 ± 0.17°C (range: 27 - 32°C) and 87.90 ± 0.99% (range: 60-98%), respectively.

RESULTS

The numbers of oothecae deposited by *P. americana* during the 17th week study period were 2169 and 2194 in release and nonrelease (control) cartons in March - June period whereas those of July - October period were 2382 and 2505 respectively in all cartons. After the release of *A. hagenowii* percent parasitism during the 0 - 7 week period was 86.7% in the release cartons which was significantly higher than in the non-release (control) cartons (9.09%) in March - June period (Fig. 1). The percent of parasitism was 95.98% in release cartons, which was also significantly higher than in non-release (control) cartons (12.55%) in July - October period (Fig. 1).

The F_1 and F_2 generations of *A. hagenowii* parasitized the oothecae deposited from 8-11 and 12-17wk, respectively. The mean percent parasitism was 89-47% (8-11 wk) and 86.49% (12-17 wk) in March - June period against 98.82% (8-11wk) and 96.20% (12-17 wk) in July-October period as recorded in the release cartons. On the other hand, in the non-release (control) cartons the percent parasitism was 46.15% (8-11 wk) and 71.62% (12-17 wk) in March-June period but 47.92% (8-11wk) and 78.57% during July-October periods respectively (Fig. 1). The results indicate that *A. hagenowii* was successfully established in the release cartons after inundative release. In the non-release (control) cartons the percent parasitism increased gradually throughout the study period which indicated that *A. hagenowii* is able to locate and search unparasitized oothecae. Although the cartons were designed to prevent escape of cockroaches, *A. hagenowii* may have escaped through the small pores and/or cracks present in the release cartons due to their small size and gregarious as well as high host searching behaviour (Narashimham 1934) and entered the non-release (control) cartons, resulting in the parasitism observed in control cartons.

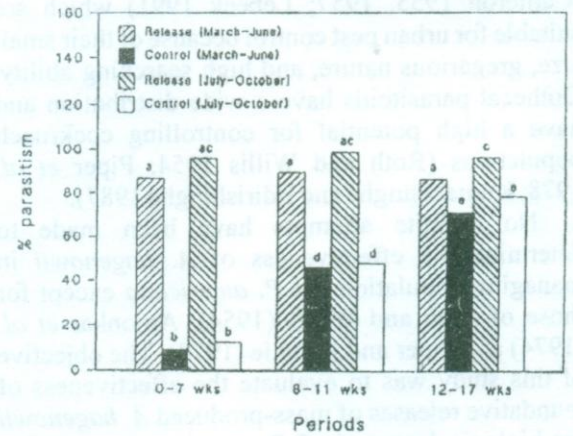

Fig. 1. Percent parasitism of viable *P. americana* oothecae by *A. hagenowii* in experimental cartons during March- June and July- October period. Bars numbered by the same letters indicate no significant difference (P>0.05) in parasitism (DMRT).

Analysis of variance showed significant differences between treatments (P<0.001) and weeks

(P<0.001). The interaction between treatment and weeks was also significant (P<0.001) in both March-June and July-October periods.

During both periods, the mean number and sex ratio (male/ female) of *A. hagenowii* emerging from paasitized oothecae were significantly (P<0.05) higher in release cartons than in non-release (control) cartons (Fig. 2). The sex-ratios (male:female) in release cartons were 1.3 : 1 in March-June and 1.4:1 in July-October periods because higher number of parasitoids were released and therefore superparasitism occurs. Sex ratio was significantly higher in release cartons than non-release (control) cartons. The mean number of

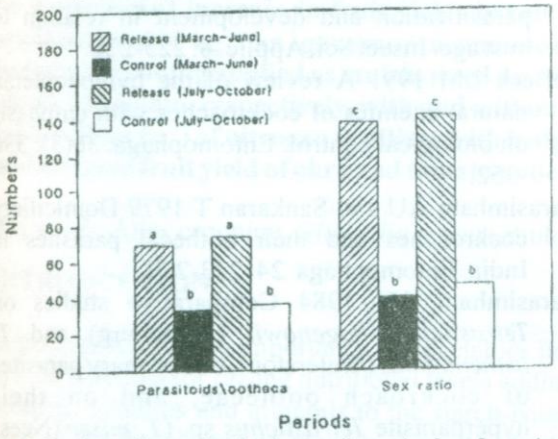

Fig. 2. Numbers and sex ratios of *A. hagenowii* emerging from *P. americana* oothecae incartons during March - June and July- October period. Bars numbered by the same letters indicate no significant difference (P>0.05) in numbers and sex ratio (DMRT).

parasitoids that emerged per oothecae from release cartons was 69.30 and 73.63 and from non-release (controls) cartons were 33.68 and 36.33 during the two periods respectively. The difference in parasitism between release and non-release (control) cartons were significant (P<0.001).

There was highly significant (P<0.001) difference in percent parasitism of *A. hagenowii* in release and non-release (control) cartons between the two experimenal periods. There was no significant difference (<0.05) in the sex-ratio in release and non-release (control) cartons. There was no significant difference (P>0.05) in the mean number of parasitoids in release and non-release (control) cartons between March-June and July-October periods.

DISCUSSION

In the present investigation the release rate of *A. hagenowii* was based on the assumption that the ideal female parasitoid:oothecae ratio would be 6:1. About 600 adults of both sexes (1:1.5 male:female) were released per carton per week. Some of the oothecae collected failed to hatch or produce parasitiods. These sterile oothecae indicate that the percent parasitism by *A. hagenowii* was 89.47% (8-12 wk) during March-June period, whereas in July-October period it was 98.82% (8-12 wk). Narasimham and Sankaran (1979) reported that field parasitism of oothecae of *P. americana* by *A. asthenogmus* was 4.7%.

Roth and Willis (1954) released adult parasitoids of *A. hagenowii* into rooms where *P. americana* oothecae were distributed and found that parasitism rates of 83 and 74% occurred when female parasitoids:oothecae ratios were 10:1 and 8:1, respectively. Adult *A. hagenowii* were able to locate and parasitize oothecae in all parts of the rooms. In another field release, Piper and Frankie (1978) found that inundative releases of *A. hagenowii* were effective against *P. americana* in closed systems. Maximal parasitism (57 - 62%) occurred when the female parasitoid:oothecae ratio was 8:1 to 12:1. Amonker *et al.* (1974) carried out a field trial of *A. hagenowii* and *P. americana* in two residential flats in India. A single release of 200 parasitoids per flat was carried out and 86.7% and 81.7% parasitism after 3 months was achieved in two flats. Oothecae collected from one of the flats at the end of 2 years were found to be parasitized to the extent of 61.5% whereas in another flat at the end of 6 and 24 months, the parasitization rate was 75% and 45.5% respectively. In another study an arbitrary number of parasitoids were released six times at weekly intervals and at the end of 22 months 66.6% of the oothecae were parasitizeed and all the parasitoid stages could be detected. Narasimham (1984) found only 8% parasitism after field release in homes, but <1% of the cockroach population was *P. americana.*

Naturally occurring populations of *A. hagenowii* have been found in both outdoors and indoors. Parasitism of *P. americana* in outdoors ranged from 46% for exposed oothecae to 73% for concealed oothecae in Taxas and Louisiana (Piper *et al.* 1978). Narasimham and Sankaran (1979) found 16% field parasitism of *P. americana* in indoors in India, indicating that *A. hagenowii* entered homes from principal outdoor locations. Fleet and Frankie (1975) reported that parasitism of *P. fuliginosa* (Serville) outdoors ranged from 22.2 to 84.2%.

There are several explanations for the high rate of parasitism.The most logical explanation is that continuous release of parasitoids into the cartons three times per week resulted in the presence of newly emerged parasitoids that actively search and parasitise host oothecae as they are deposited. Moreover, *A. hagenowii* probably lived longer under field conditions where water and food are readily

available than under laboratory conditions. Consequently, the parasitoid: host ratio would be higher due to greater longevity of parasitoids. The sued in this study had an excellent searching ability as indicated by parasitization of oothecae in the non-release (control) cartons. The male-biased sex ratio resulting from superparasitism with more males above to complete development than females (Roth and Willis 1954; Askew 1971) lead us to conclude that 8.3:1 (female parasitoid: ootheca) release rates were too high for sustained inundative releases and should be lowered for optimal production of female parasitoids during subsequent generations.

Based on the above findings, it can be concluded that *A. hagenowii* has the potential for biological control of *P. americana*. Moreover, the parasitoid is easily reared in the laboratory and under limited, simulated field conditions exhibited excellent searching ability, parasitizing oothecae. Sustained inundative releases resulted in the establishment of reproducing parasitoid populations having the capacity to bring about 92% parasitism through the F_2 generation.

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