

Studies on egg and nymphal parasites of rice planthoppers, *Nilaparvata lugens* (Stål) and *Sogatella furcifera* (Horvath)*

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Abstract. Three species of egg parasites, viz., *Anagrus* sp., *A. optabilis* (Mymaridae) and *Oligosita* sp. (Trichogrammatidae), and a nymphal/adult parasite *Gonatopus* sp. of rice planthoppers were studied for their biology and control potential. Larger number of adult mymarids emerged from host eggs between 8.30 a.m. and 12.30 p.m. of the day whereas trichogrammatid adults emerged between 12.30 p.m. to 4.30 p.m. All the three species parasitised both brown planthopper (BPH) and white backed planthopper (WBPH) but, in general, failed to parasitise rice leafhoppers.

Developmental duration from oviposition to adult emergence noted for these parasites indicated that males of mymarids, in general, developed faster (10-11 days) than females (12-13 days) at 20-32°C prevailing during October, whereas *Oligosita* females developed more slowly (14-15 days). However, both *A. optabilis* and *Oligosita* developed three days faster at 30-38°C prevailing during April. Fecundity in terms of number of eggs parasitised per female varied from 12.3 to 20.3. Under greenhouse conditions, release of 1 and 5 pairs of mymarid parasites for 10 days reduced the nymphal hatch of BPH by 60 and 85%, respectively. Nymphal/adult parasite *Gonatopus* sp. completed its life cycle in 19.5 to 31 days on both BPH and WBPH. While the 4th and 5th instar nymphs of BPH were parasitised more frequently, green leafhopper nymphs were not parasitised. Besides being endoparasitic, the adult females also predated on and killed as many as 5.2 nymphs a day.

Keywords. *Anagrus* spp. *Gonatopus* ; parasitoids ; rice planthoppers.

1. Introduction

Rice planthoppers have gained major pest status causing 'hopper burn' in several rice growing Asian countries. Outbreaks of brown planthopper *Nilaparvata lugens* (Stål) have been reported in different parts of India (Kalode 1974 ; Kulshrestha *et al* 1974). Also, white backed planthopper, *Sogatella furcifera* Horvath, is noted to cause damage in northern India (Verma *et al* 1979), while smaller brown planthopper, *Laodelphax striatellus* (Fallen) has been reported from the Punjab (Shukla 1979).

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Twentyfour species of egg parasites and 30 species of nymphal parasites have been recorded mainly on brown planthopper (BPH), besides three species of nematode parasites, 11 species of pathogenic fungi and 61 species of insect and spider predators are also reported (Anonymous 1978 ; Manjunath 1978 ; Manjunath *et al* 1978 ; Chiu 1979).

From India, except for a brief account of *Anagrus* sp. (Samal and Misra 1978), no detailed study seems to have been made of egg or nymphal/adult parasites of rice planthoppers. In the present investigation 3 species of egg parasites, viz., *Anagrus* sp., *Anagrus? optabilis* (Perkins) (Mymaridae) and *Oligosita* sp. (Trichogrammatidae) and nymphal adult parasite, *Gonatopus* sp. (Dryinidae) were investigated with respect to their biology, host range and biocontrol potential against the planthoppers. *A. optabilis* has been reported here for the first time from India, while genus *Gonatopus* on BPH is a new record.

2. Materials and methods

2.1. Rearing

2.1a *Egg parasites*: Rearing was initiated with the parasitised eggs collected from rice plants in the field and glasshouse. Leaf sheaths of plants were peeled out and kept in glass jars containing a little water at the bottom and covered by an inverted glass funnel. A glass tube was kept inverted on the glass funnel. Adults emerging from host eggs through leaf sheaths moved upwards and were collected in the glass tubes. Populations of parasites were further built up by exposing new plants to parasites on which eggs had been freshly laid and later keeping such plants in jars for adult collection (figure 1). All the three species of parasites were reared together. Only for experimental purpose adult parasites were differentiated under binocular microscope. Except when specified, rearing and biology studies were carried out in the laboratory at room temperature ranging from 20-38° C and, humidity varying from 30 to 80% RH.

2.1b *Nymphal parasite* : Parasite pupae from affected brown planthopper culture in glasshouse were collected in tubes to initiate rearing. Emerging *Gonatopus* adults were fed with honey solution, and mated females were released on T(N)1 rice plants along with the nymphs of BPH and WBPH. Adult parasites were transferred every day to fresh plants with healthy nymphs kept in separate cages to avoid nymphal mortality due to predation. All the studies were conducted in the glasshouse with host insects reared on T(N)1 plants at $30 \pm 5^\circ \text{C}$ and $80 \pm 10\% \text{RH}$.

2.2. Experiments

Studies on egg parasites were carried out using individual rice seedlings (15-20 day old) kept in test tubes. Gravid females of BPH/WBPH were confined in such tubes for 24 hr for oviposition prior to the release of parasites. After 6-7 days plants were dissected to count number of eggs parasitised and such eggs were then kept on moist filter paper in glass tubes with screw caps to observe adult emergence.



Figure 1. Laboratory rearing method for the egg parasites of rice planthoppers *Nilaparvata lugens* and *Sogatella furcifera*. Adult planthoppers are released on T(N)1 plants for oviposition (pot 1), followed by parasite release for parasitisation (pot 2). After healthy planthopper eggs hatch (pot 3), plants are cut to be kept in adult emergence jars to collect the emerging adults.

Life cycle of nymphal parasite, *Gonatopus*, was studied by offering planthopper nymphs to mated females confined on rice plants in mylar film cages. Similar set-up was used for experiments to determine suitable nymphal instar for parasitization, host range and to estimate predation by adults.

3. Results

3.1. Egg parasites

3.1a *Adults*: Mymarid adults (*Anagrus* spp.) are brown in colour with fringed wings, body measuring 0.7 to 0.9 mm in length, while *Oligosita* is greenish yellow in colour with smaller body of about 0.5 mm with rounded wings. However, *Anagrus* sp. has bulkier abdomen with short ovipositor whereas *A. optabilis* has a slender abdomen with long and prominent ovipositor. In the laboratory population of mymarids, females were more numerous than males (sex ratio of 5 females : 1 male). The virgin females parasitised host eggs normally thus indicating thelytokous development. Adults of mymarids lived for 24–36 hr without any food and those of *Oligosita* survived for 24–48 hr. Males of *Oligosita* were not observed and hence this species appears to be uniparental.

Adult emergence patterns were noted for the three species by recording the number of adults emerging during different time intervals of the day. Results, illustrated in figure 2, indicated more than 70% of mymarid adults emerged between 8.30 a.m. and 12.30 p.m., whereas maximum percentage of trichogrammatid adults emerged between 12.30 p.m. and 4.30 p.m.

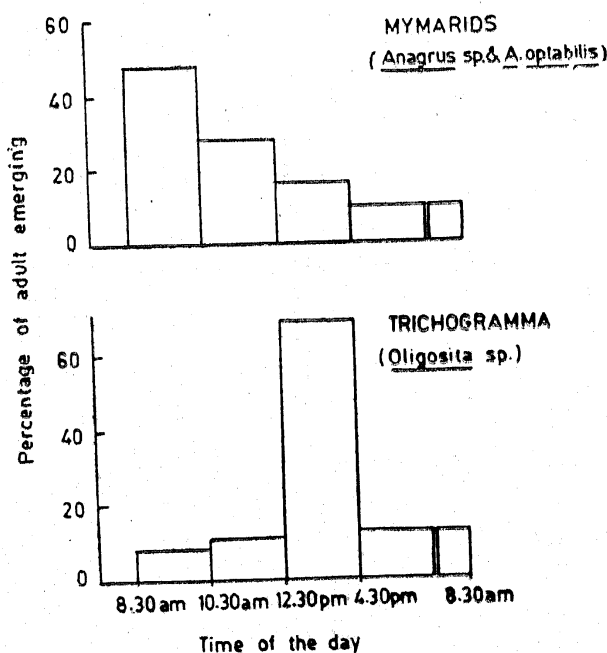


Figure 2. Adult emergence patterns for mymarid (*Anagrus* sp. and *A. optabilis*) and trichogrammatid (*Oligosita* sp.) egg parasites of rice planthoppers *Nilaparvata lugens* and *Sogatella furcifera*. It may be noted that while mymarids emerge before noon, trichogrammatids emerge during afternoon.

3.1b *Developmental duration and fecundity*: The entire life cycle of egg parasites was completed inside the host egg. All three species parasitised the eggs of both brown planthopper and white backed planthopper. Eggs parasitised by mymarids turned yellow by day 7, assuming orange to red-brown colour by day 8 and 9 when pupation occurred inside the eggs. Those parasitised by *Oligosita* turned greenish yellow by 7-8th day without further change in colour.

The data on duration of development, presented in table 1, indicated that males of mymarids, in general, developed faster (10-11 days) than females (12-13 days) while the *Oligosita* females developed slowly (14-15 days) at 20-32° C prevailing during October 1979. However, both *A. optabilis* and *Oligosita* developed 3 days faster at 30-38° C prevailing during April 1980. A female mymarid could parasitise 15-20 planthopper eggs whereas that of the *Oligosita* parasitised 12-18 eggs.

3.1c *Host range* : As noted above the 3 species of parasites readily parasitised both the species of rice planthoppers. However, they failed to parasitise eggs of rice leafhoppers, viz., *Nephotettix* spp., *Inazuma dorsalis* and *Tettigella spectra*.

3.1d *Biocontrol potential* : An experiment was conducted under glasshouse conditions to note the potential of mymarid parasites in checking egg hatching of brown planthopper. One pair of newly emerged brown planthopper was first caged on T(N)1 plants followed by daily release of one and five pairs of *Anagrus* parasites into the cage from day 5 to day 15. As indicated in table 2, release of 1 pair of mymarids reduced the egg hatch by about 60%, while release of 5 pairs reduced it by 85% indicating a high biocontrol potential of the egg parasites.

Table 1. Developmental duration and fecundity of egg parasites of planthopper, *Nilaparvata lugens* (BPH) and *Sogatella furcifera* (WBPH).

Parasite	Host	Development duration* (days)		Fecundity (no. of eggs parasitised/ female)
		Male	Female	
<i>Anagrus</i> sp.	BPH	13.5	12.6	20.3
	WBPH	...	10.8	14.5
<i>A. optabilis</i>	BPH	11.0	12.1 9.2**	17.5
	WBPH	10.4	12.1	19.0
<i>Oligosita</i> sp.	BPH	...	13.8 10.6**	18.0
	WBPH	...	15.3	12.3

* Development observed during October 1979 (temp. ranging 20.1 to 31.8° C) and

** April 1980 (29.1 to 38.0° C).

Table 2. Influence of mymarid parasites (*Anagrus* spp.) on hatching of *Nilaparvata lugens* eggs.

Treatment	No. of eggs hatched/ female* Mean \pm SE	% reduction in viability
Control	439.3 \pm 50.3 ^a	...
1 pair of parasites released from day 5 to 15	199.3 \pm 25.7 ^b	59.5
5 pairs of parasites released from day 5 to 15	66.2 \pm 11.4 ^c	84.9

* mean of 6 replications.

comparison of means : a-b ; a-c and b-c, $p < 0.001$ (*t*-test).

3.2. Nymphal parasite

3.2a Adults : Adult female *Gonatopus* resembles an ant in appearance but can be distinguished from the latter by the presence of chelate fore tarsi adapted for catching the prey. While the females are apterous (figure 3), males have membranous wings and are more active than females. Body size is smaller (2 to 3 mm in length) in the case of males than in females which measure 4 to 5 mm in length, and have a dark black body. Adult longevity ranged from 7 to 10 days for males and 15 to 20 days for females when provided with honey solution.

Lifecycle of *Gonatopus* was studied by offering nymphs of both BPH and WBPH to mated females for oviposition and later observing these nymphs periodically. The female parasite holds 4th or 5th instar planthopper nymphs with its forelegs, bends its abdomen and thrusts eggs into the host body (figure 3). The parasitised nymphs are immobilised for 2-3 min before they move off. Since eggs are laid internally, incubation period could not be exactly determined, but small black or yellow sac-like structures (larval sacs) appear on the abdomen of nymphs 3-5 days after oviposition (figure 3). The larval sacs, one or two per nymph, containing larvae enlarge gradually. At the end of the larval period, ranging from 7 to 12 days, the larval sac bursts and a small 2-4 mm long yellowish white or sometimes pinkish larva crawls out killing the host. Prepupal stage lasts for 12 to 24 hr and pupation takes place either on the rice plant or on the sides of cages. Prior to pupation, the larva secretes an yellowish-white fluid to form a membranous, oval shaped puparium (figure 3). Adults emerge after 9 to 12 days. The total life cycle of *Gonatopus* takes 19.5 to 31 days on BPH and 24.5 to 31 days on WBPH (table 3).

Since the dryinid normally selects only older nymphs or adult hosts for oviposition, suitability of different nymphal instars for parasitisation was studied. As presented in table 4, maximum parasitisation (larval sacs) per female was observed

Table 3. Life cycle of nymphal parasite, *Gonatopus* sp. on *Nilaparvata lugens* and *Sogatella furcifera*.

Host	Incubation period (days)	Larval period (days)	Pre-pupal period (hours)	Pupal period (days)	Total developmental duration (days)
<i>N. lugens</i>	3-5	7-12	12-24	9-13	19.5-31.0
<i>S. furcifera</i>	3-5	10-12	12-24	11-13	24.5-31.0

Table 4. Parasitisation of different instar nymphs and adults of *Nilaparvata lugens* by *Gonatopus* sp.

Host instar	No. of insects studied*	No. of parasites released	No. of nymphs parasitised	Av. No. of nymphs parasitised/female/day
1st instar nymph	80	8	0	0
2nd instar nymph	80	8	0	0
3rd instar nymph	80	8	8	1
4th instar nymph	80	8	40	5
5th instar nymph	80	8	48	6
Adults	80	8	24	3

* based on four replications at 20 insects/replication.

in 5th instar nymphs (av. number 6) followed by 4th instar nymphs (5) and adults (3).

3.2b *Host range* : Host range and preference for parasitisation by *Gonatopus* was noted by offering 4th and 5th instar nymphs of BPH, WBPH and green leafhoppers (*Nephotettix* spp.). It is evident from table 5, that *Gonatopus* preferred BPH to WBPH since 13 out of 30 BPH nymphs were parasitised as against 9 of WBPH, while it did not parasitise green leafhopper nymphs.

3.2c *Nymph predation* : Besides parasitisation of older nymphs, *Gonatopus* females were also observed to predate on younger nymphs. The observation on the extent of nymphal predation showed that one female could kill on an average 5.2 nymphs per day. These findings revealed that dryinid, *Gonatopus*, had a good biocontrol potential against planthoppers both as nymphal/adult parasite as well as nymphal predator.

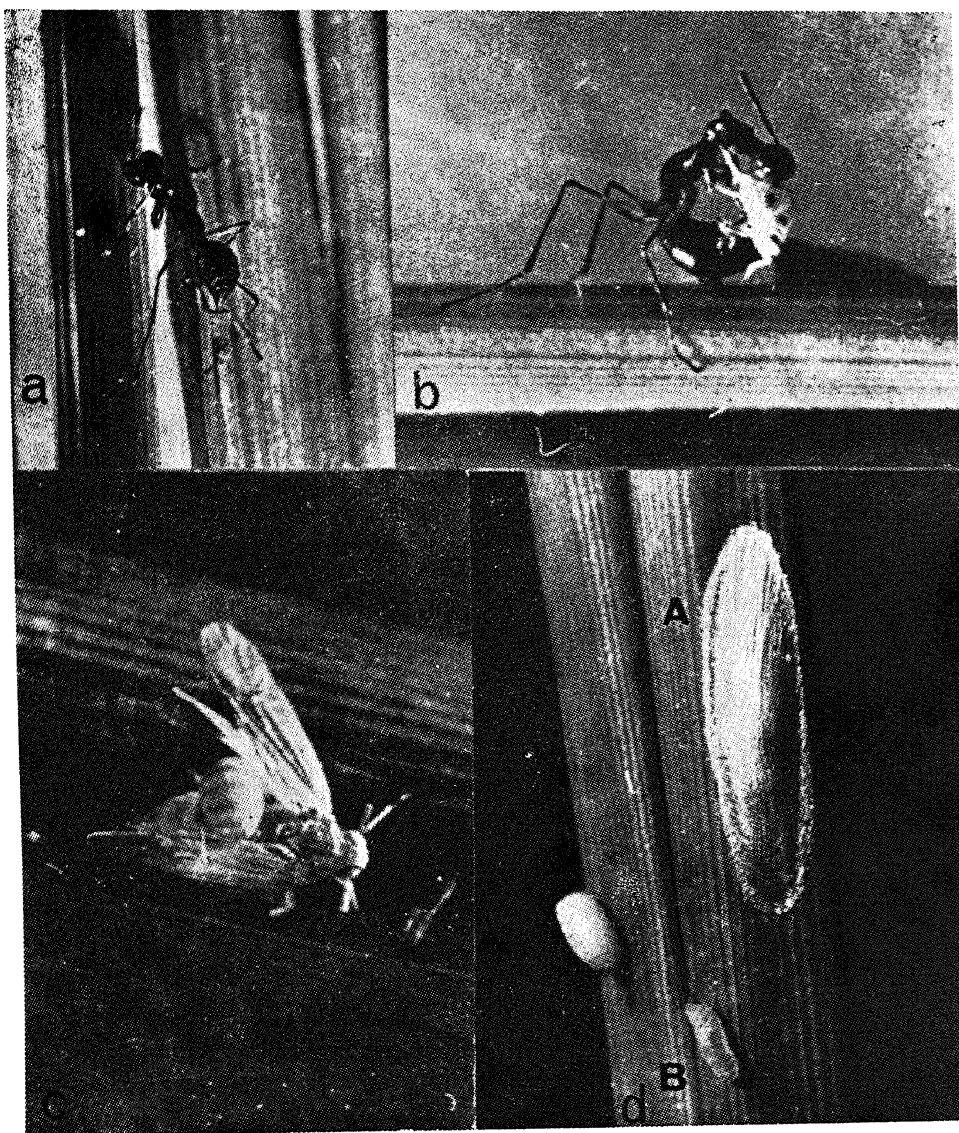


Figure 3. Nymphal/adult parasite (*Gonatopus* sp.) of rice planthoppers, *Nilaparvata lugens* and *Sogatella furcifera*. **a.** Apterous adult female ; **b.** a prey being held by a female for oviposition ; **c.** an adult planthopper with larval sac ; **d.** fully grown larva (**B**) and pupa in puparium (**A**).

Table 5. Host range and preference for parasitisation by *Gonatopus* sp.

Host	No. of host insects studied*	No. of parasites released	Cumulative number of insects parasitised after...	
			3 days	5 days
Brown planthopper	30	15	10	13
White backed plant-hopper	30	15	5	9
Green leafhopper	30	15	0	0

* Total of 3 replications at 10 insects/replication.

4. Discussion

Adult emergence pattern has been noted for *Paracentrobia andoi*, a trichogrammatid egg parasite of the leafhopper, *Nephotettix cincticeps* (Vungsilabutr 1978). Most of the adults emerged between 8 a.m. and 12 noon. In the present work, while mymarids had a peak emergence before noon, trichogrammatid adults emerged during afternoon. Samal and Misra (1978) noted the development period for *Anagrus* sp. to be 12 to 14 days during April–May with temperatures ranging from 24.4 to 35° C. Our results for *Anagrus* sp. show that the developmental period was 11 to 14 days during October. The parasite took lesser time to develop on WBPH than it did on BPH. It is not known, however, if these two species of parasites are the same or different. Temperature effects on the rate of development have been elaborately investigated for *P. andoi* (Vungsilabutr 1978). Though in the present study constant temperatures were not maintained, differences in developmental duration observed for *A. optabilis* and *Oligosita* sp. noted during October (temp. ranged from 20.1 to 31.8° C) and April (29.1 to 38° C) essentially reflect the effect of temperature.

Though all the three species readily parasitised both BPH and WBPH eggs, mymarids failed to parasitise leafhoppers. The preference of mymarid parasites among the planthoppers and host range of the trichogrammatid are yet to be studied in detail. It is not uncommon, however, for an egg parasite to have both leaf and planthopper hosts as noted for *P. andoi* (Vungsilabutr 1978) and many other species (Anonymous 1978).

Studies on *Gonatopus* sp. substantiate the view that dryinids would make good agents for biological control of injurious *Cicadellidae* and *Fulgoridae* (Olmi 1976).

Biological control of rice planthoppers through the use of natural enemies has so far not been attempted in field scale. However, the only suggested candidate for this purpose—the egg-nymphal predator *Cyrtorhinus lividipennis* has a wider range of predation (Bentur and Kalode 1980). In contrast, the egg parasites and

the nymphal parasite investigated in the present work have host range restricted only to brown planthopper and white backed planthopper and also possess a good degree of control potential. They can also be considered for use in field along with *C. lividipennis*. Nevertheless, development of economical mass rearing methods, information on the behaviour of released population under field conditions and knowledge of mutual interaction of natural enemies are prerequisites for any such attempts.

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