

## New natural enemy complex of some fulgoroids (Insecta: Homoptera) with biological studies of three hymenopterous parasites (Insecta: Hymenoptera)

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**Abstract.** Natural enemy complex of the planthoppers, *Dichoptera hyalinata* F., *Eurybrachys tomentosa* F., and *Ricania fenestrata* F. includes two nymphal ectoparasites (*Dryinus* spp.), two egg parasites (*Proleurocerus fulgoridis* F. and *Tetrastichus* sp.), an internal larval mermithid parasite, and a predator (*Phidippus* sp.). Biological aspects of *Dryinus* spp. and *P. fulgoridis* are discussed.

**Keywords.** Fulgoroidea; natural enemies; parasite; predator.

### 1. Introduction

The planthoppers, an economically very important group as pests and vectors of plant diseases, were investigated in relation to their association with crops as well as their natural enemies. In India the bionomics and effectiveness of the natural enemies of fulgoroids were studied extensively with reference to *Pyrilla* spp. (Rahman and Ramnath 1940; Rahman 1941; Sen 1948; Narayanan and Kundanlal 1953; Subba Rao 1957); *Nilaparvata lugens* Stål (Abraham *et al* 1973; Kalode 1976; Manjunath 1978; Manjunath *et al* 1978a,b; Rai and Chandrasekhar 1979; Samal and Misra 1975, 1978a,b) and *Sogatella fuscifera* Horvath (Chaudhury and Ramzan 1968; Israel and Prakasa Rao 1969). The present paper brings to light the occurrence of new natural enemies of the fulgoroids, *Eurybrachys tomentosa* F. (Eurybrachidae, Fulgoroidea), *Ricania fenestrata* F. (Ricaniidae, Fulgoroidea) and *Dichoptera hyalinata* F. (Dictyopharidae, Fulgoroidea), the first two being pests of important crops such as *Santalum album*, *Zizypus jujuba*, *Cajanus indicus*, *Calotropis gigantea*, *Camellia sinensis*, *Gossypium* spp., *Jasminum flexile*, etc. (Chatterjee 1933; Hutson 1919; Light 1929; Puttarudriah and Maheswariah 1958). Besides, the biology of two ectoparasites, *Dryinus* spp. (Dryinidae, Bethyloidea) and an egg parasite, *Proleurocerus fulgoridis* F. (Encyrtidae, Chalcidoidea) are discussed.

## 2. Material and methods

The parasitized eggs (in the case of egg parasites) and nymphs (in the case of ectoparasites) were brought from the field and reared in the laboratory for adult emergence. The emerged adult parasites were caged in small glass chimneys (110 ml) or plastic vials (10 ml, 15 ml) (figure 1A), and were fed with a dilute sucrose solution soaked in cotton, the latter being fixed on a wire projecting inside the containers. Freshly laid egg masses of *E. tomentosa* and fresh nymphs of *E. tomentosa* and *D. hyalinata* were provided in the cages for the egg parasites and ectoparasites respectively to enable the parasites to lay their eggs. From the day of parasitization, one egg from the same batch of parasitized eggs was dissected out daily to study the sequence of changes in the life cycle of the egg parasites. Parasitized host nymphs were caged separately and the larval development of the ectoparasites was observed. The larvae of the ectoparasites emerging from the hosts were allowed to pupate on a glass surface (figure 2C), which enabled observation of pupal development. Laboratory conditions during the present study were 19° C–37° C (temperature) and 60%–90% (relative humidity).

## 3. Observations

### 3.1. Incidence of new parasites and predators

The nymphs of *D. hyalinata* were parasitized by an ectoparasite, *Dryinus* sp. (A)\* (Dryinidae), while another dryinid, *Dryinus* sp. (B)\*, was recorded on the nymphs of *E. tomentosa*. The eggs of *E. tomentosa* were parasitized by an encyrtid, *Proleurocerus fulgoridis*, and an eulophid, *Tetrastichus* sp., while the adults of this insect were parasitized by a larval mermithid. In the case of *R. fenestrata* a salticid predator, *Phidippus* sp., was recorded as a natural enemy (figures 1B to 1F).

Observations on the seasonal cycles of the parasites (figure 3) revealed that *Dryinus* sp. (A) occurred in the field for 7 months, *P. fulgoridis* for 5 months, *Dryinus* sp. (B) for 3 months, and *Tetrastichus* sp. for a month. *Dryinus* sp. (A) was at the peak of its activity during November followed by the absence of the host's nymphal population during the four succeeding months, and their parasitic activity was minimum during July. *P. fulgoridis* was very active during February and March, when all the egg masses of *E. tomentosa* collected from the field were found to be parasitized by this parasite. Parasitization by *Tetrastichus* sp. was minimal, occurring only during April. Both *P. fulgoridis* and *Tetrastichus* sp. parasitized the same egg mass of *E. tomentosa* and in one instance the former parasitized 35 eggs of an egg mass, the latter 39 eggs. Occurring on its host only during winter months, the ability of *Dryinus* sp. (B) to suppress the population of its host, *E. tomentosa* appeared to be less pronounced than that of *Dryinus* sp. (A) on its host, *D. hyalinata*. Adults of *E. tomentosa* affected by a larval mermithid endoparasite were also identified and the parasitized adults appeared pale and

\* The two *Dryinus* spp. have been designated as (A) and (B) as they have been identified to be two new species (Dr Z Boucek, Commonwealth Institute of Entomology, London—Personal communication). Being very host specific the identity of the species (A) and (B) would not be confusing.

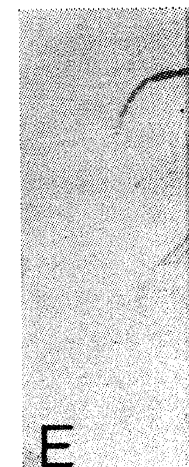
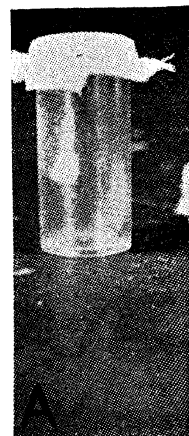


Figure 1.  
D. *Phidippus*  
D, F—Sc

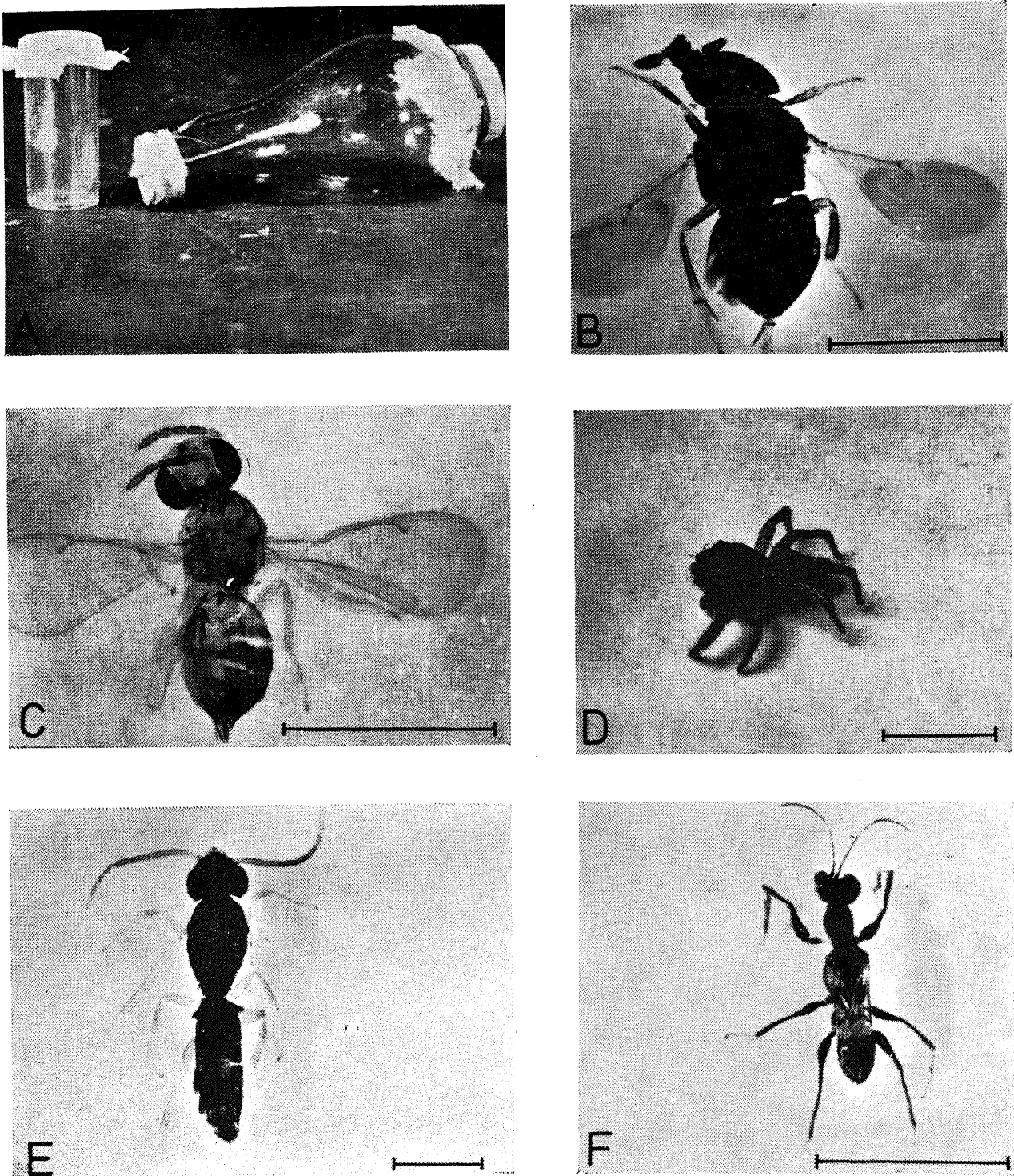


Figure 1. A. Rearing cages for the parasites, B. *Proleurocerus fulgoridis*, C. *Tetrastichus* sp., D. *Phidippus* sp., E. *Dryinus* sp. (B). Male, F. *Dryinus* sp. (A)—Female (B, C, E—Scale = 1 mm ; D, F—Scale = 5 mm).

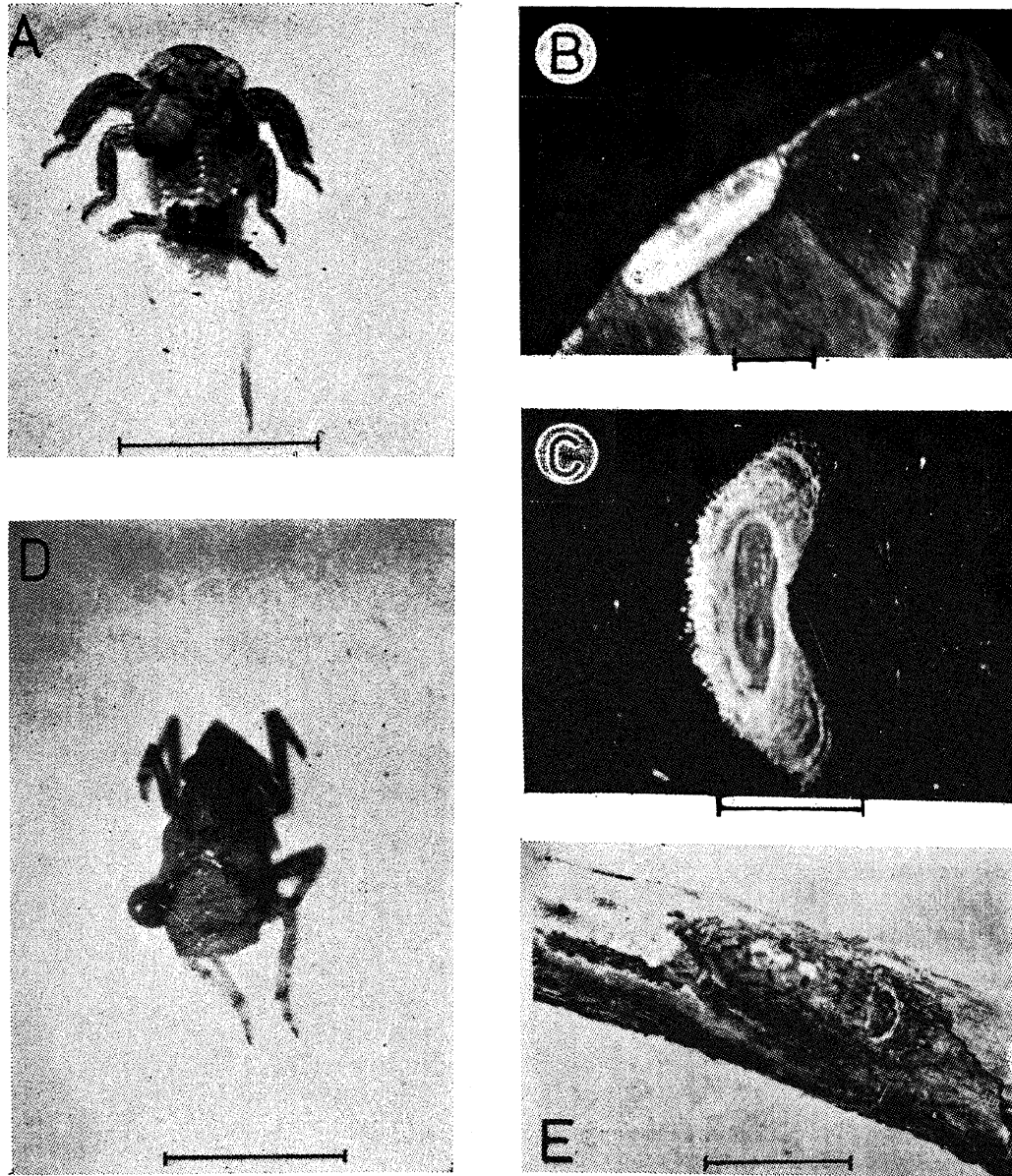


Figure 2. A. Parasitized *E. tomentosa* nymph showing thalacium. B, C. Pupa of *Dryinus* sp. (B). D. Parasitized *D. hyalinata* nymph showing thalacium. E. Pupa of *Dryinus* sp. (A) (Scale = 5 mm).

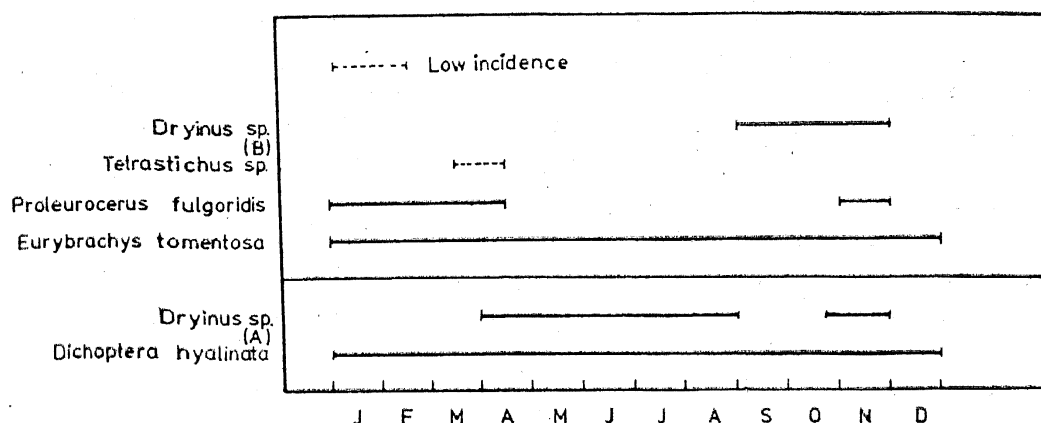


Figure 3. Seasonal cycle of host and parasites.

seemed distinctly inactive. All the life stages of *R. fenestrata* except eggs were actively predated upon by the spider, *Phidippus* sp. (Salticidae, Arachnida) in the field as well as under laboratory conditions. Besides feeding on *R. fenestrata*, *Phidippus* sp. also fed on other insects found in the same habitat, but less frequently.

### 3.2. Biology of parasites

3.2a *Dryinus* sp. (B):—The adult parasites with a shining black body were observed in the field actively moving around the plants in search of their host. When the parasite actively chased the host for oviposition, a distinct parasitic behaviour was noticed (Swaminathan and Ananthakrishnan 1981). Mostly second and third instars of the host were preferred for parasitization by the females, while in the laboratory they were able to parasitize the first, second, and third instars, and sometimes the fourth instar nymphs as well. The fifth instar nymphs of the hosts easily escaped from the attack of the parasite by kicking and jumping. In all the first instar host nymphs examined, the egg-deposition and development of the 'thalacium' were noticed only under the hind wing pad, while in the second and third instar host nymphs, parasitization was under both the wing pads. In the fourth instar nymphs, the parasite larva failed to develop after a certain stage; even in cases when it successfully completed its delayed larval life, and left the host, it finally died before spinning the cocoon. The average time taken to complete oviposition increased as the size of the host increased in the successive instars, being 95 sec, 117.9 sec, 172.5 sec, and 235 sec in first, second, third, and fourth instars respectively. The time interval between two successive acts of oviposition was 5–10 min. Eggs were usually laid beneath the wing pads and in the laboratory each host carried only one egg. *Dryinus* sp. (B) female laid more than one egg/host under different wing pads if the same host was exposed for a long time and no other hosts were available. A minimum of 1 egg/host and a maximum of 2 eggs/host were recorded in the laboratory, but in the field the host nymphs generally showed only one egg.

The eggs were elongate, cylindrical and translucent. In dryinids the first larval instar is spent entirely within the host (Clausen 1940). Three to four days after

oviposition the parasite developed a bag-like structure (figure 2A) at the oviposited site on the host's body. This bag-like structure the 'thalacium', was suggested to be formed by a proliferation of the host integument (Subba Rao 1957). The cyst membrane of the thalacium is found all over the parasite larva thus preventing direct contact of the larva with the body cavity of the host and the larva derives all food material through this membrane (Clausen 1940). The whitish and translucent thalacium gradually turned brown after 3 days. The parasite larva developed inside the thalacium slowly sucking the haemolymph of the host without affecting the latter's life activities. With the establishment of the thalacium on host, the planthopper nymphs lost their ability to moult further, particularly when the nymphs were parasitized at the end of their stadial period. In the laboratory only in three instances two larvae were found to develop on a single host. Such parasites developed one on either side or on the same side under the wing pads. If two thalacia developed from the same host, only one parasite larva fully completed its development and successfully pupated while the other showed partial development ultimately perishing along with the host. Within the thalacium the larva underwent three moults, and the mature larva sucked out most of the haemolymph of the host before leaving it. The resultant enlargement caused a cleavage line antero-posteriorly in the thalacium, through which the emerging parasite larva crawled out and dropped down to the substratum. Owing to extensive feeding by the escaping larva, the host suffered excessive shrinkage and died. The mature larva (2.5-4 mm long and 0.75-1 mm wide) appeared dull white in colour with a pointed anterior end and bulging posterior end. It soon started building a white cocoon on the leaves or stems (figure 2B). In the laboratory, the cocoon spinning was also noticed on the wall of the glass containers (figure 2C) and cloth, within 5 min of escape from the host. While spinning the pupal case with white silken threads secreted from the mouth, the larva entered the cocoon by peristaltic movements. The large well-developed mandibles were efficiently used in cocoon building, particularly in cutting the threads. The fully formed cocoon was generally oval, double-walled—a tightly-spun inner and loosely-spun outer wall—measuring on an average 7 mm long and 2½ mm wide.

Though the parasite larva entered the cocoon immediately after leaving the host, the actual pupation took place only after 4-5 days. During this period the brownish larva showed peristaltic movements inside the cocoon, subsequently turning reddish brown, and resulting in a complete pupa exhibiting swift and frequent back and forth movements for 10 days. On the 7th-8th day after spinning cocoon, wings and limb buds developed and the demarcation of the head, thorax, and abdomen was evident. During the late pupal period there was a deposition of black excretory material in the caudal end of the cocoon. On the 15th day after spinning the cocoon, the pupa turned fully black and there was a cessation of movements.

The active male and female adults emerged from the cocoon by making a hole at the anterior end. Both parthenogenetic and sexual reproduction were observed, the former always resulting in male offspring. Under laboratory conditions the average life span of adult female and male was 25 days and 16 days respectively, the average oviposition period of females being 20 days and the average total number of eggs laid by a single female was 35. The average total duration of egg, larval,

Table 1. Duration of various stages in the life-cycle of parasites (in days).

Species	Period between egg-laying and thalacium formation	Duration of the larval stage spent in thalacium	Period spent in the cocoon	Total life-cycle
<i>Dryinus</i> sp.(A)	3	4	23	30
	4	6	23	33
	2	4	25	31
	6	6	26	38
	6	5	23	34
Mean	4.2 ± 1.6	5 ± 0.89	24 ± 1.27	33.2 ± 2.79
<i>Dryinus</i> sp. (B)	4	8	25	37
	3	8	22	33
	3	9	23	35
	3	12	23	38
	4	8	23	35
Mean	3.4 ± 0.49	9 ± 1.55	23.2 ± 0.98	35.6 ± 1.74
	Egg	Larva	Pupa	Total
<i>Proleurocerus fulgoridis</i>	2	3	4	9
	2	4	5	11
	2	4	4	10
	2	4	9	15
	2	4	10	16
Mean	2 ± 0	3.8 ± 0.4	6.4 ± 2.58	12.2 ± 2.79

and pupal periods was 35.6 ± 1.74 days and the parasite spent more time in the cocoon (23.2 ± 0.98 days) than in the thalacium (9 ± 1.55 days) (table 1).

3.2b *Dryinus* sp. (A) : The life cycle appeared similar to that of *Dryinus* sp. (B) with only some minor variations. The average total duration of egg, larval, and pupal periods was 33.2 ± 2.79 days (table 1). Eggs were laid beneath the wing pads, in the dorsal middle region of the thoracic segments, and on the dorsal lateral region of the abdominal segments. Midthoracic region was highly preferred for egg laying. Each host carried 1-2 parasite larvae both under laboratory and field conditions.

The larvae developed inside the thalacium (figure 2D) which was gelatinous white during the first day of its formation and turned brown after 2-3 days. As in *Dryinus* sp. (B), when parasitized by two larvae, one developed faster than the other and pupated, while the other died with the host. The larva underwent three moults inside the thalacium. While leaving the host, the larva fed on most of the

host haemolymph and escaped from the thalacium by rupturing it while the host was killed. Immediately after leaving the host, the larva formed an oval cocoon with two walls of silken threads on the bark of the host plant (figure 2E). The colour of the cocoon varied with the surrounding and was brownish (on bark in the field) or grey (on cloth in rearing cages in the laboratory). Both in the laboratory and under field conditions the second, third, and fourth instar host nymphs were susceptible to parasite attack. All the behavioural patterns and methods of oviposition were similar to those of *Dryinus* sp. (B).

3.2c *Proleurocerus fulgoridis*: The eggs of this encyrtid parasite were fusiform and stalked. The average length and width of the eggs were  $507.5 \mu$  and  $160.2 \mu$  respectively, while the stalk measured  $267.0 \mu$ . The eggs were laid singly within the host egg. The durations of egg and larval stages were 2 days and  $3.8 \pm 0.4$  days respectively (table 1). On the second and third day of larval development the larva grows to a maximum size by consuming all the contents of the host egg. The fully grown larva measured 1.78 mm long and 0.68 mm wide with 12 segments (figure 4). During the development of the larva of the parasite the host egg showed no colour change. Inside the host egg a constant peristaltic movement of the parasite larva was noticed. Pupation resulted on the 5th or 7th day of parasitization and the pupal period lasted  $6.4 \pm 2.58$  days (table 1). With the pupation of the parasite the colour of the host egg changed to brown. The host nymphs from unparasitized eggs in a partially parasitized egg mass always hatched 1-2 days before the parasites emerged.

The adult parasites (figure 1B) were shiny black and started mating as they emerged from the host egg. The males chased the females and while moving in front of the females, vibrated their half-extended wings. The longevity of the adults was 2-4 days when fed with 5% sucrose solution. The females started laying eggs shortly after emergence. Young host egg masses (2-3 days old) were preferred for oviposition. Usually 1-2 females attacked a single egg mass under field conditions. Each female took 5-6 hr to complete egg laying. As soon as a gravid female located a fresh egg mass of *E. tomentosa*, it moved over it for sometime and then started laying eggs. After making punctures on the waxy coat at many places, the females inserted their ovipositors and laid eggs. Superparasitism was not observed. In the egg masses of *E. tomentosa* 40.59%-100% of the eggs were found parasitized under field condition (table 2).

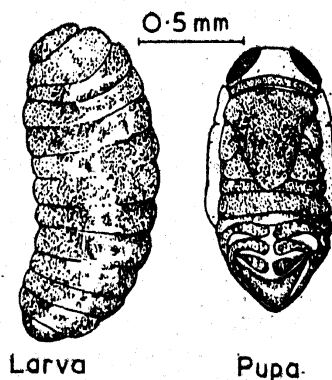


Figure 4. Immature stages of *Proleurocerus fulgoridis*.



Table 2. Percentage parasitization of individual egg masses of *Eurybrachys tomentosa* by *Proleurocerus fulgoridis* under field condition.

Total number of eggs in a mass	Number of parasitized eggs	Number of unparasitized eggs	Percentage of eggs parasitized in a mass
114	111	3	97.36
106	103	3	97.16
101	41	60	40.59
110	110	...	100.00
123	105	18	85.37
100	97	3	97.00
103	102	1	99.02
90	90	...	100.00
91	91	...	100.00
83	83	...	100.00
57	56	1	98.24
98 ± 17.7	89.9 ± 22.4		92.3 ± 17.6

#### 4. Discussion

A high degree of host preference is exhibited by Dryinidae commonly found as parasites of both adults and nymphs of Fulgoroidea and Cicadellidae and they are known to be either solitary or gregarious (Clausen 1940). Observations of Subba Rao on *Lestodryinus pyrillae* Kieff (1957), Swaminathan and Ananthakrishnan (1981) on two *Dryinus* spp., and the present study shows the following characteristic features of these effective biological control agents: (i) The dryinids are host specific, an important quality for effective biological control agents as suggested by DeBach (1964); (ii) They show preference for nymphal stages; (iii) Oviposition behaviour like chasing, pouncing, and paralyzing is exhibited by the females; (iv) The dryinids exhibit arrhenotoky; and (v) The parasitized nymphs are prevented from moulting to the next instar. Similarly other dryinids, *Pseudogonatopus hospes* Perk. (Pagden 1934) and *Dicondylus lindbergi* Heikinheimo (Heikinheimo 1957) were found to prefer the last two instars of *Delphacodes furcifera* Horvath and adults of *Delphacodes pellucida* F. respectively. The present study was confined to the effects of parasitism by the dryinids on nymphs of the host. Hence the effects of parasitism on adult hosts such as deformities in reproductive organs and external sex reversal in males (Clausen 1940) was not studied. There are five larval instars in dryinids (Clausen 1940), of which the first is seen inside the host body, the following three are spent inside the thalacium, the fifth one escaping and crawling away from the host for pupation. In the present investigation also, similar larval instars were noticed including three moults in the thalacium.

No natural enemies have so far been recorded from *E. tomentosa*, *R. fenestrata*, and *D. hyalinata*, the first two being pests of important crops (vide introduction). In *E. tomentosa* all the life stages—eggs, nymphs, and adults are parasitized by the natural enemies. In *R. fenestrata* the eggs are laid inside the plant tissue. Hence the nymphs and adults are alone predated by the spider and in *D. hyalinata* only the nymphal stages are attacked by the natural enemy. All the natural enemies reported here appear to be new records. Under field condition the *E. tomentosa* egg masses were parasitized to a maximum extent (100%) by *P. fulgoridis* which shows the latter to be a promising biological control agent of the former.

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