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NATURAL ENEMIES OF RICE LEAF FOLDER, *CNAPHALOCROCIS MEDINALIS* GUENÉE (PYRALIDAE : LEPIDOPTERA)—A CRITICAL REVIEW (1913-1983)

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ABSTRACT

A chronological review of the biological control agents of rice leaf folder, *Cnaphalocrocis medinalis* Guenée, including the stage of host attacked in different countries, their activity and suggestions for future.

*Additional index words* : Rice leaf folder, *Cnaphalocrocis medinalis* Guenée, Parasitoid, Predator, Pathogens.

The rice leaf folder, *Cnaphalocrocis medinalis* Guenée, which was a pest of minor importance till the last decade, recently has assumed major importance in many rice ecosystem of Asia, the South Pacific Islands, Hawaii and Australia (Hirao, 1982). Increasingly frequent outbreaks of this pest (Table 1) in recent years have been attributed to the introduction of modern rice technologies, namely : Continuous and overlapping cropping (Rajamma and Das, 1969); introduction of broad leaf dwarf, high tillering, fertilizer responsive susceptible rice varieties (Gargav and Katiyar, 1971; Dorge *et al.*, 1972; Patel, 1975) and increased use of nitrogenous fertilizers (Michael Raj and Morachan, 1973; Chandragiri *et al.*, 1974; Subbaiah and Morachan, 1974; Dhaliwal *et al.*, 1979; Chantaraprapha *et al.*, 1980; Miyahara, 1981). In addition shading which causes the rice plants to grow tall with reduced silica content may make plants more susceptible (Chelliah, 1983). However, no detailed information is available as to how these factors bring about favourable conditions for larval growth and survival and or cause enhanced fecundity of the adults.

The indiscriminate use of insecticides has had remarkable effects on distribution and relative importance of insect pest species (Heinrichs and Mochida, 1984). Lack of adequate knowledge on proper application techniques and dosages and frequent use of broad spectrum insecticides has contributed to a change in the status of *C. medinalis* by killing its natural enemies (Chelliah, 1983; Chelliah and Heinrichs, 1983). It has thus become a well known menace to rice cultivation in various rice growing regions, including International Rice Research Institute,

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**Table 1.** Outbreaks of rice leaf folder, *Cnaphalocrocis medinalis* Guenée in various countries

Location	Year(s) of Outbreak	Reference	Remarks
<b>Bangladesh</b>			
Dacca	April-May, 1977	Anonymous (1977)	—
China	1967, 1970, 1971, 1972, 1974, 1981	Chang <i>et al.</i> (1980) Hirao (1982)	—
China, Kiangsu Province	1970, 1973, 1977 1979, 1981	Chang <i>et al.</i> (1980) Hirao (1982)	—
<b>India</b>			
Cochin	1938-39	Anonymous (1941)	Injurious for the first time
Raipur	Kharif 1969-70	Gargav and Katiyar (1971)	—
Maharashtra (Thana, Kolaba, Vengurla and Sawantwadi)	Second fort night of June 1970	Dorge <i>et al.</i> (1972)	Serious outbreak.
Madhya Pradesh (Chhatisgarh region)	1968	Patel (1975)	Regularly occurring since 1968 and has been established a major pest.
North Bengal (Coochbihar, Jalpaiguri)	1978	Chatterjee (1979)	Endemic proportions on upland drilled autumn rice.
Uttar Pradesh (Pantnagar)	Kharif 1977	Verma <i>et al.</i> (1979)	First outbreak in 1977.
Japan	1967, 1971, 1973, 1975, 1977, 1980, 1981	Hirao (1982)	1980 outbreak was the largest, both in area involved and in severity of damage. The total infested area was 491, 182 ha corresponding to 22% of total cropping area.
Kyushu (South- west of Japan)	1973, 1975 1973, 1975, 1977, 1978, 1979, 1980, 1981.	Wada <i>et al.</i> (1981) Hirao (1982)	Outbreak occurred 73% infested in 1980 followed by 67% during 1975.
Korea	1963, 1967, 1971, 1973, 1978, 1981	Hirao (1982)	—

experimental farm (Gonzales, 1974). The direct effects of application of Phorate 10 G granules to control other rice pests in vegetative stage of the crop has induced an outbreak of *C. medinalis* either by killing of its natural enemies and or by increased attractancy due to plant growth stimulation (Chelliah, 1983).

One of the major components in the success of IPM programmes is knowledge of the naturally-occurring biological control agents. Hence an attempt is made here to review works from 1913 to 1983 on natural enemies of *C. medinalis*.

The natural enemies of the rice leaf folder, *C. medinalis*, which include parasitoids, predators and pathogens, have been reported from different countries. Vincens (1920) emphasized the importance of natural enemies which keep the population of the leaf folder under check and suggested that no additional control measures are needed. Similarly Goco (1921) reported parasitoids and predators checked the activity of the leaf folder in the Philippines. Recently, Yasumatsu *et al.* (1976) listed parasitoids and predators of *C. medinalis* in Thailand and indicated the importance of conserving the natural enemies and their utilization in integrated control programmes. Great importance has been placed on biological control agents and their use in rice insect pest management. In an integrated pest control programme in Guangdong Province, China, the use of insecticide was limited to a very low level and as a result 97.9 per cent of rice leaf roller, has been checked by its natural enemies (Li, 1982).

**Parasitoids and Predators** : Earlier records of parasitoids by Sakai *et al.* (1942), Hsia (1957) and Cendana and Calora (1964) failed to identify the specific species involved and later workers reported the species of parasitoids and predators recorded from different countries (Tables 2, 3, 4). Field releases of *Trichogramma* sp., an egg parasitoid, successfully controlled *C. medinalis* in China (Li, 1978), and parasitized 60–70 per cent of leaf folder eggs in India (Yadava, 1980) and 21 per cent in mid-September in Japan (Kobayashi and Wada, 1981).

In Japan, *Tratha flavorbitalis* (Cam) was reported to parasitize 30 per cent of *C. medinalis* larvae, in July (Wada and Shimazu; 1978) and 34 to 54 per cent in late June and early July (Kobayashi and Wada, 1981). While at the end of August 12 per cent of *C. medinalis* larvae, was parasitized by *Apanteles* sp. (Wada and Shimazu, 1978).

Pupal parasitization up to 11 per cent by *Brachymeria excarinata* Gahan was observed during late October (Kobayashi and Wada, 1981).

The gregarious ectoparasitoid, *Goniozus indicus* Muesebeck has been successfully reared on leaf folder larvae (Abraham *et al.*, 1974). After detailed biological studies Kamal (1981) stated that a female *G. indicus* laid an average of three eggs

Table 2. Hymenopterous parasitoids of the rice leaf folder, *Cnaphalocrocis medinalis* Guenée

Natural enemy family and Scientific Name (1)	Host Stage attacked <sup>a</sup> (2)	Location (3)	References (4)
<b>Bethylidae</b>			
<i>Gonizus</i> sp. near <i>depressus</i> Kieffer	L	India	Rao (1964)
<i>G.</i> nr <i>indicus</i> Muesebeck	L	Philippines	Kamal (1981)
<i>G. indicus</i> Muesebeck	L	Philippines	Barrion <i>et al.</i> (1979)
<i>G. triangulus</i> Kieffer	L	India	Rao (1964)
<i>G.</i> spp.	L	India	Rao (1964)
	L	India	Abraham <i>et al.</i> (1974)
<b>Braconidae</b>			
<i>Apanteles</i> sp.	L	Japan	Kobayashi & Wada (1981)
	L	—	Greathead (1979)
<i>A. angaleti</i> Muesebeck	L	India	Talgeri and Dalaya (1971)
<i>A. angustibasis</i> Gahan	— <sup>b</sup>	Malaya	Wilkinson (1934)
	—	Philippines	Otanes & Sison (1941)
	—	Malaya	Thompson (1945)
<i>A. flavipes</i> Cameron	L	Sri Lanka	Rohan <i>et al.</i> (1982)
<i>A. syleptae</i> Ferriere	L	India	Talgeri & Dalaya (1971)
	L	India	Abraham <i>et al.</i> (1974)
<i>Bracon gelechtiae</i> Ashmead	L	India	Talgeri & Dalaya (1971)
<i>Cardiochiles</i> sp.	—	India	Thompson (1945)
<i>C. philippinensis</i> Ashmead	L	Philippines	Barrion <i>et al.</i> (1979)
<i>Chelonus</i> spp.	L	Philippines	Kamal (1982)
<i>Coelinus</i> sp.	L	India	Abraham <i>et al.</i> (1974)
<i>Macrocentrus</i> sp.	—	Malaya	Thompson (1945)
<i>M. philippinensis</i> Ashmead	L	Philippines	Barrion <i>et al.</i> (1979)
<i>Microbracon hebetor</i> Say.	L	Sri Lanka	Rohan <i>et al.</i> (1982)
<b>Ceraphronidae</b>			
<i>Aphanogmus fijiensis</i> Ferriere	L	Philippines	Kamal (1981)
<b>Chalcididae</b>			
<i>Brachymeria</i> sp.	—	India	Talgeri & Dalaya (1971)
<i>B. excarinata</i> Gahan	P	Philippines	Gahan (1925)
	P	Philippines	Otanes & Sison (1941)
	—	Philippines	Thompson (1945)

Contd.—

(1)	(2)	(3)	(4)
	P	India	Rao (1964)
	P	Philippines	Baltazar (1966)
	P	Philippines	Barrion <i>et al.</i> (1979)
	P	India	Abraham <i>et al.</i> (1974)
	—	—	Greathead (1979)
	P	Japan	Kobayashi & Wada (1981)
<i>B. obscurata</i> (Walker)	—	India	Talgeri & Dalaya (1971)
<i>B. tachardiae</i> (Cameron)	L, P	Philippines	Kamal (1981)
<b>Elasmidae</b>			
<i>Elasmus</i> sp.	L	India	Abraham <i>et al.</i> (1974)
<i>E. brevicornis</i> Gahan	—	India	Talgeri & Dalaya (1971)
<i>E. corbetti</i> Ferriere	L	Malaya	Ferriere (1930)
	—	Malaya	Thompson (1945)
	L	—	Greathead (1979)
<b>Encyrtidae</b>			
<i>Pentalitamastix</i> sp.	E, L	Philippines	Kamal (1981)
<b>Eulophidae</b>			
<i>Pediobius</i> sp.	—	India	Rao (1964)
<i>Sympiesis</i> sp.	—	India	Rao (1964)
<i>Syntomosphyrum obscuripes</i> Ferriere	—	India	Talgeri & Dalaya (1971)
<i>Trichosphilus pupivara</i> Ferr.	—	India	Thompson (1945)
	P	India	Anantanarayana (1934)
<i>Tetrastichus ayyari</i> Rohwer	—	India	Rao (1964)
		—	Greathead (1979)
<i>T. israeli</i> (Mani & Kurien)	P	India	Abraham <i>et al.</i> (1974)
	P	—	Greathead (1979)
<i>T. schoenobii</i> Ferriere	L	Philippines	Kamal (1981)
<b>Ichneumonidae</b>			
<i>Chorinaeus facialis</i> sp. Nov.	P	Fujian Zhejiang, Guangdong & Honan, Prov., China	Chao (1981)
<i>Cremastus biguttulus</i> Munakata	L	—	Sakai <i>et al.</i> (1942)
<i>Diocetes vulgaris</i> Marley	L	—	Sakai <i>et al.</i> (1942)

Contd.-

(1)	(2)	(3)	(4)
<i>Eriborus reyukyuensis</i> (Mornoi)	—	Japan	Kusigemati (1976)
<i>Leptobatopsis indica</i> Cameron	—	India	Rao (1964)
<i>Nesopimpla naranyae</i> Ashmead	L	—	Sakai <i>et al.</i> (1942)
<i>Paniscus testaceus</i> Grar	L	East Pakistan	Alam <i>et al.</i> (1965)
<i>Pristomerus</i> sp.	—	India	Rao (1964)
<i>Syzenctus</i> sp.	—	India	Rao (1964)
<i>Temelucha</i> sp. near <i>beoimacula</i> (Cameron)	L	India	Rao (1964)
<i>T. philippinesis</i> Ashmead	L	Philippines	Kamal (1981)
<i>T. stangli</i> (Ashmead)	L	Philippines	Barrion <i>et al.</i> (1979)
<i>Tratha flavoorbitalis</i> (Cameron)	—	Japan	Kusigemati (1976)
	—	Japan	Kobayashi & Wada (1981)
<i>Xanthopimpla emaculata</i> Szepl.	—	India	Thompson (1945)
	—	—	Greathead (1979)
<i>Nythobia</i> sp.	L	India	Lingappa (1972)
<i>Xanthopimpla flavolineata</i> Cameron	L	Philippines	Barrion <i>et al.</i> (1979)
<i>X. lepcha</i> Cameron	L	East Pakistan	Alam (1965)
<i>X. trifasciata</i> Smith	L	India	Reddy and Rao (1977)
<b>Pteromalidae</b>			
<i>Eupteromalus</i> spp.	L, P	India	Rao (1964)
<i>Pachyneuron</i> sp.	L	Philippines	Kamal (1981)
<b>Trichogrammatidae</b>			
<i>Trichogramma</i> sp.	E	China	Li (1978)
	E	India	Yadava (1978)
	E	—	Greathead (1979)
	E	India	Yadava (1980)
	E	Japan	Kobayashi & Wada (1981)
	E	Philippines	Kamal (1981)

• E—egg; L—larva; P—pupa

• —no information available

Table 3. Dipterous parasitoids of rice leaf folder, *Cnaphalocrocis medinalis* Guenée

Natural enemy family and Scientific name	Host stage attacked <sup>a</sup>	Location	References
<b>Chloropidae</b>			
<i>Scoliophthalmus micans</i> Lamb	— <sup>b</sup>	India	Talgeri & Dalaya (1971)
<b>Phoridae</b>			
<i>Megaselia scalaris</i> (Loew)	L/P	Philippines	Kamal (1981)
<b>Tachinidae</b>			
<i>Agryophylax fransseni</i> (Baranov)	L/P	Java, Malaysia	Thompson (1945)
<i>Ceromosis</i> sp.	L	Japan	Sakai <i>et al.</i> (1942)
	L/P	—	Greathead (1979)
<i>Chaetexorista javana</i> (B.B)	L/P	India	Rao (1964)
	L/P	—	Greathead (1979)
<i>Nemorilla floralis</i> (Fallen)	L	Japan	Sakai <i>et al.</i> (1972)

<sup>a</sup> L—Larva, P—Pupa

<sup>b</sup> —no information available

Table 4. Predators on the rice leaf folder, *Cnaphalocrocis medinalis* Guenée

Natural enemy order, Family and Scientific name (1)	Host stage attacked <sup>a</sup> (2)	Location (3)	Reference (4)
<b>1. Araneida</b>			
<b>Araneidae</b>			
<i>Argiope amulus</i> (Aud.)	A	Philippines	Barrion <i>et al.</i> (1979)
<i>A. catenulata</i> (Doleschall)	A	Philippines	Kamal (1981)
<i>A. sp.</i>	A	Philippines	Kamal (1981)
<b>Lycosidae</b>			
<i>Lycosa pseudoannulata</i> (Boes & Str.)	E, L, A	Philippines	Kamal (1981)
<b>Oxyopidae</b>			
<i>Oxyopes javanus</i> Thorell	L, A	East Pakistan	Alam (1965)
	L, A	Philippines	Barrion <i>et al.</i> (1979)
	A	Philippines	Barrion <i>et al.</i> (1979)

Contd.—



(1)	(2)	(3)	(4)
Tetranathidae			
<i>Tetragnatha</i> sp.	A	East Pakistan	Alam (1965)
<i>T. japonica</i> (Boes & Str.)	E, A	Philippines	Kamal (1981)
2. Coleoptera			
Carabidae			
<i>Chlaenius</i> sp.	L	Philippines	Barrion & Litsinger (1980)
	L	Philippines	Kamal (1981)
<i>Desera geniculata</i>	L	Philippines	Barrion <i>et al.</i> (1979)
Coccinellidae			
<i>Coccinella arcuata</i> (Fabricius)	E, L	Philippines	Kamal (1981)
<i>Coccinella</i> sp.	L	Philippines	Kamal (1981)
<i>Menochilus sexmaculatus</i> (Fabricius)	L	Philippines	Kamal (1981)
3. Hemiptera			
Pentatomidae			
<i>Andrallus spinidens</i> (Fabr.)	L	India	Rao & Rao (1979)
4. Hymenoptera			
Formicidae			
<i>Camponotus</i> nr. <i>denestivus</i> Wheeler	L	Philippines	Barrion & Litsinger (1980)
<i>C.</i> nr. <i>nawai</i> Ito	L	Philippines	—do—
<i>Diacamma</i> sp.	L	Phil. & Batangas Province	—do—
<i>Odontoponera</i> sp.	L	Philippines	—do—
<i>O. transversa</i> (F. Smith)	L	Philippines	—do—
<i>Pheidole</i> sp.	L	India	Das <i>et al.</i> (1974)
<i>Solenopsis germinata</i> (F.)	L	Philippines	Barrion & Litsinger (1980)
	E, L	Philippines	Kamal (1981)

<sup>a</sup> E—egg, L—larva, A—adult

per day and produced 35 eggs throughout its life span. A female can parasitize 16 host larvae and neither cannibalism nor hyperparasitism occurred.

Das *et al.* (1974) observed the activity of ants (*Pheidole* sp.) in upland and lowland rice. The adults reached the plants on floating materials. He further

observed that workers were more active than soldiers and preferred third and fourth-instar larvae and consumed 15 larvae/15 minutes. Similarly, Barrion and Litsinger (1980) observed that workers of *Diacamma* sp. transport 4-10 larvae/hour and the peak activity is from 0900 to 1030 and from 1600 to 1730 hours.

The role of predators in larval mortality of leaf folders under Philippines field conditions is suspected because only 14 per cent parasitization was recorded (Kamal, 1981). Kamal further reported, 94 per cent larval mortality in the field. She further stated that the egg predation capacity (no. of prey killed/predator/day) of the adult spider, *Tetragnata Japonica* (Boes & Str.), the adult of spotted beetle *Coccinella arcuata* Fabricius, and the ant, *Solenopsis germinata* (F.) was 15.1, 13.3 and 11.8 respectively, whereas the larval predation 1.3 by *Chlaenius* sp. The spider, *Lycosa pseudoannulata* (Boes & Str.) fed on the adult leaf folder with a predation capacity of 1.6.

**Pathogens :** Literature on microbial control is limited. However, the potential of insect pathogens as biological control agents are great (Gabriel, 1975).

The wide spread occurrence of white Muscardine disease on leaf folders caused by *Beauveria bassiana* Balls, has been reported by Rao (1975) at Cuttack. Later, work on pathogenicity and infectivity of the entomogenous fungi, *Syncephalastrum racemosum* Cohn ex Schroeter and *Penicillium oxalicum* Currie and Thom. was reported by Philip *et al.* (1981) under laboratory conditions.

Rangaswami *et al.* (1969) reported a bacterium (unidentified) attacking larvae and pupae at Annamalai Nagar, Tamil Nadu. Two commercial preparations of the *Bacillus thuringiensis* Berliner, namely Dipel at 0.5 kg/ha and Bactospeine at 1.5 kg/ha under laboratory conditions, at IRRRI, caused 100 per cent mortality of leaf folder larvae at 5 days after treatment (IRRI, 1974). In observations during 1976, at Cuttack, Srivastava and Nayak (1978) reported 80 per cent mortality of leaf folder larvae when inoculated with *Serratia marcescens* Bizio. The same authors during 1978 also made studies on comparative laboratory efficacy of four formulations of *B. thuringiensis* Berliner and revealed that "Thuricide" and "Dipel" were superior to "Bactospeine", and "Cajrab". Yang (1978) also reported the effectiveness of *B. thuringiensis* against the rice leaf folder in China. More than 50 strains of *B. thuringiensis* have been studied in China under field conditions and of which *B. thuringiensis* var. *galleriae* is the most common (Li, 1982).

Steinhaus and Marsh (1962) first reported the incidence of a granulosis virus on leaf folder in Fiji and Jacob *et al.* (1973) isolated and tested the pathogenicity

of this virus on leaf folder at Trivandrum, Kerala. The diseased larvae turned milky white and migrated towards the leaf tip before drying. During 1978, in China, Pang *et al.* (1981) reported an epizootic of granulosis virus among larvae of rice leaf folder on a late rice crop and identified it as baculovirus.

*Neoplectana carpocapsae* Weiser (DD136), is the only known insect parasitic nematode reported on the leaf folder larva (Israel *et al.*, 1969).

**Future Research Priorities :** There is an urgent need for detailed investigations on the biology of the different biocontrol agents since almost no information is available. This will aid the identification of the most promising species which can play an important role in rice leaf folder population management.

The efficacy and minimum rates of pesticides against the leaf folder and their safety to the natural enemies must be investigated. Pesticides should be screened for safety against all stages of the natural enemies.

Carry over of the natural enemies needs special attention, since during off season, rice leaf folder is present on grasses and so it is of paramount importance to know parasite and predator carry over.

Many of the natural enemies of leaf folder are also reported to parasitize other common rice pests and so host specificity of the natural enemy is important to know. This will also help to develop a mass rearing techniques for some biological control agents.

Studies to confirm the status of the parasitoids reported earlier whether primary/secondary parasitoids are needed.

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