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Campoletis chlorideae Uchida (Hymenoptera: Ichneumonidae) as a parasite of *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae) in southwest India

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Abstract. *Campoletis chlorideae* Uchida was the most common parasite emerging from the larvae of *Helicoverpa armigera* (Hub.) collected during 1974–83 from almost all of its crop and weed hosts from Andhra Pradesh, Karnataka and Maharashtra. In most years, parasitism was highest in September and lowest in May. At ICRISAT Center, during 1977–83, the average percentage parasitism of first to third instar larvae, which are only parasitised by *Campoletis chlorideae,* was 44·2 on sorghum, 33·1 on chickpea, 32·6 on pearl millet, 7·1 on groundnut and 4·2 on pigeonpea. Parasitism in pesticide-treated crops was lower than in untreated crops. Ten species of hyperparasites were recorded from cocoons of *Campoletis chlorideae.* Hyperparasitism was around 40% on cereals and 10% on legumes.

Keywords. Parasitism; hyperparasitism; *Campoletis chlorideae*; *Helicoverpa armigera.*

1. Introduction

Campoletis chlorideae Uchida, misidentified until 1980 successively as *Horogenes fenestralis* Holmgren (Tikar and Thakare 1961), *Campoletis perdistinctus* Viereck (Gangrade 1964), *Ecphoropsis perdistinctus* Viereck (Mathur and Dharmadhikari 1970) and *Diadegma* sp. (Bhatnagar and Davies 1979), is one of the most common larval parasites of *Helicoverpa armigera* (Hub.) in India (Bilapate *et al* 1979; Yadav *et al* 1982). The parasite deposits eggs singly in first or second instar host larvae, which usually die in the third or fourth instar. The fully grown parasite larva leaves the host to spin a cocoon and pupate on the plant. A detailed biology and ecology of this parasite in India is described by Patel and Patel (1972) and of the related species, *C. sonorensis* (Cameron), in the USA by Danks *et al* (1979). This paper describes the field observations on the parasite and its role in the natural control of *H. armigera.*

2. Materials and methods

During 1974–83, *H. armigera* larvae were collected from a range of crops and weeds from large areas of the states of Andhra Pradesh, Karnataka and Maharashtra (figure 1). They were reared in the laboratory at 25 ± 2°C and 60–70% RH to record parasite emergence.

H. armigera larvae were also collected at ICRISAT Center, Patancheru from sorghum, pearl millet, groundnut, pigeonpea and chickpea. Unlike in the survey, they were grouped as 1–3 instar and 4–6 instar larvae to record parasitism.

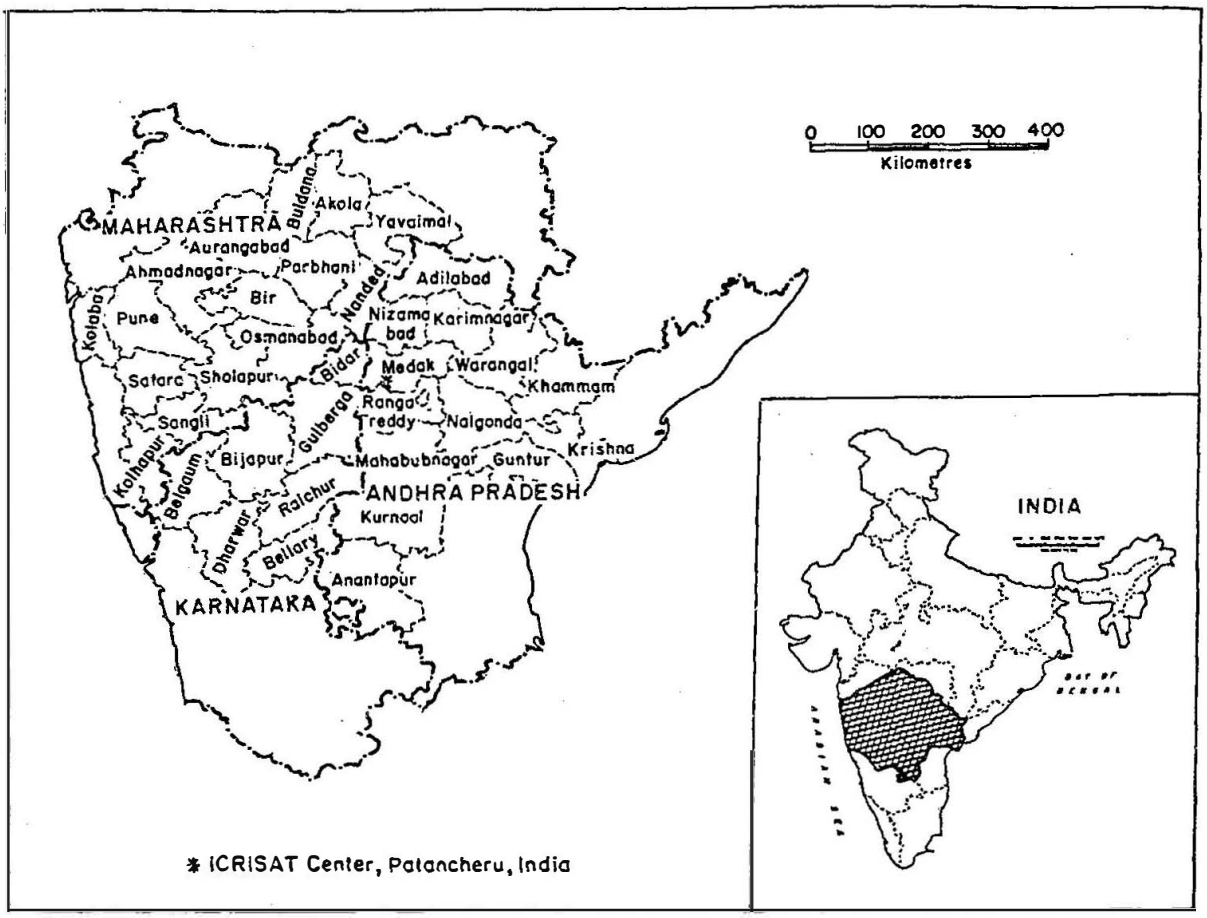

Figure 1. Area covered in survey for *Helicoverpa* parasite in India (1974–85).

Pesticide treated pigeonpea and chickpea were sampled separately. Cocoons of *C. chlorideae* were collected to investigate the extent of hyperparasitism.

The total per cent and the degree of parasitism by *C. chlorideae* alone in *H. armigera* larvae were estimated irrespective of the larval instar for the surveyed area. However, for ICRISAT Center the parasitism by *C. chlorideae* in 1–3 instar larvae was estimated separately to indicate precisely its impact on the mortality of *H. armigera* on ICRISAT crops.

3. Results

3.1 *C. chlorideae on different crops and weeds*

C. chlorideae parasitised *H. armigera* larvae on almost all the crops and weeds covered in the survey at all times of the year (table 1). It was, however, most abundant in cereal crops where it parasitised 23·0, 16·6 and 4·1% of *H. armigera* larvae on sorghum, pearl millet, and maize respectively. On these crops *C. chlorideae* accounted for 60–85% of the total larval parasitism of *H. armigera.*

Among the legumes, the parasitism of *H. armigera* larvae by *C. chlorideae* was highest on chickpea (16·3%), followed by soybean (12·8%), groundnut (4·2%) and cowpea (2·4%). These figures represented 40–80% of the total parasitism on these crops.

Table 1. Average parasitism (%) of larvae of *H. armigera* by *C. chlorideae* in relation to total larval parasitism in different crops and weeds and its distribution across months in Andhra Pradesh, Karnataka and Maharashtra, 1974–85.

	Overall larval parasitism@ (%)	Parasitism by *C. chlorideae* alone (%)	*C. chlorideae* parasitism across months											
			Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Cereals														
Sorghum	27·2 (37003)	23·0	0·0	0·0	16·3	26·6	0·0	9·7	21·1	0·0	3·4	0·0	0·0	0·0
Pearl millet	22·6 (1423)	16·6	—	—	16·5	17·1	—	—	18·7	—	—	—	—	0·0
Maize	6·4 (2241)	4·1	—	0·0	4·6	3·1	—	10·0	—	25·0	0·0	—	0·0	0·0
Legumes														
Pigeonpea	14·5 (89602)	0·9	—	0·2	0·0	2·6	3·4	0·7	0·9	0·7	0·1	0·4	0·0	0·0
Chickpea	20·6 (60793)	16·3	0·0	1·3	6·1	15·1	27·9	17·3	24·1	16·3	14·0	11·3	43·7	1·4
Groundnut	12·8 (7351)	4·2	0·2	1·2	8·5	7·5	—	—	—	9·9	2·9	1·4	4·7	2·1
Cowpea	4·0 (6316)	2·4	—	1·5	0·0	—	—	17·1	—	—	—	0·0	1·6	3·0
Mungbean	4·4 (682)	0·1	—	—	0·0	4·5	—	—	—	—	—	—	—	—
Soybean	26·3 (133)	12·8	—	—	—	0·0	0·0	13·9	—	—	—	—	—	—
Pea	63·6 (11)	63·6	—	—	—	—	—	—	—	63·6	—	—	—	—
Oilseeds/fibre														
Safflower	31·5 (5316)	21·1	—	—	50·0	—	—	14·7	22·9	20·5	82·2	—	—	—
Sunflower	8·3 (96)	5·2	—	—	0·0	8·9	0·0	—	—	0·0	—	—	—	—
Linseed	24·8 (2060)	6·8	—	—	—	—	—	44·4	6·4	6·9	—	—	—	—
Cotton	12·8 (201)	12·8	—	—	—	12·8	—	—	—	—	—	—	—	—
Vegetable														
Tomato	8·5 (2613)	4·4	0·0	0·9	0·7	4·0	—	0·0	—	0·0	0·0	19·0	0·0	2·1
Weeds														
Cardiospermum halicacabum	14·3 (7)	14·3	—	—	—	—	—	—	—	—	14·3	—	—	—
Cleoma gynandra	37·6 (2301)	4·6	0·0	0·2	1·1	—	—	—	—	—	—	—	64·0	6·7
Gomphrena celosioides	30·9 (5785)	14·6	0·0	0·0	10·8	38·5	44·2	—	—	—	0·0	—	—	0·0
Hibiscus panduraeformis	14·3 (28)	3·6	—	—	—	—	—	—	—	—	3·6	—	—	—
Sesbania bispinosa	27·0 (679)	3·7	—	—	—	21·7	1·8	—	—	—	—	—	0·0	—
Cumulative parasitism			0·1 (1146)	0·6 (7294)	11·3 (16114)	25·7 (30136)	12·8 (12012)	4·4 (52493)	8·3 (31384)	9·2 (33860)	10·6 (16613)	8·0 (12612)	6·6 (5740)	2·3 (5237)

@Total parasitism in larvae inclusive of all parasites, insects and nematodes. Numbers in parentheses refer to a total number of larvae collected, 1974–85.

On safflower, tomato and sunflower *C. chlorideae* parasitised 21·1, 4·4 and 5·2% of the *H. armigera* larvae respectively. Substantial parasitism was also recorded on weeds particularly *Gomphrena celosioides* (L.).

3.2 *C. chlorideae on crops at ICRISAT Center*

H. armigera occurs throughout the year at ICRISAT Center (Pawar *et al* 1984) from July–September on groundnut, sorghum and pearl millet and from October–February on pigeonpea and chickpea (figure 2A). Small numbers are found on the post-rainy crops of groundnut and also of sorghum and pearl millet (December–May). These numbers, however, decline since the crops at ICRISAT Center are progressively cleared by May.

C. chlorideae parasitised *H. armigera* on all these crops. The average rate of parasitism varied with the crop type but was highest on sorghum (44·2%); this was followed by chickpea (33·1%), pearl millet (32·6%), groundnut (7·1%) and pigeonpea (4·2%). Parasitism was highest in September, when the overall parasitism in 1–3 instar larvae reached 46%, but it tended to decline from September to

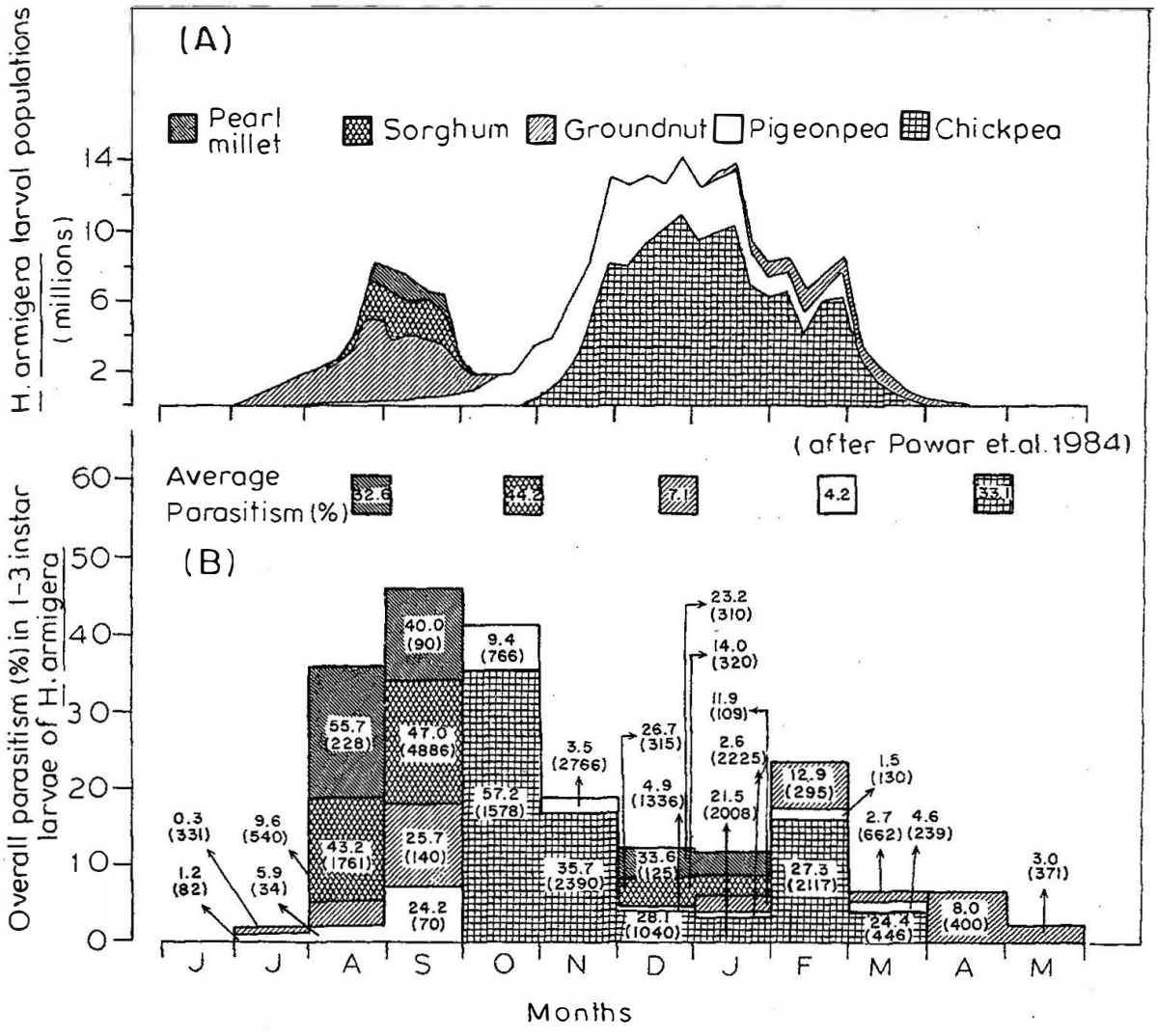

Figure 2. **A.** Average populations of *H. armigera* larvae on crops. **B.** Average parasitism (%) by *C. chlorideae* in 1–3 larvae of *H. armigera*, ICRISAT, 1977–83.

January as the *H. armigera* populations increased. This was followed by a slight rise in the overall parasitism during February as the *H. armigera* populations receded.

3.3 *Effect of insecticide application on parasitism*

The crops of pigeonpea and chickpea at ICRISAT Center receive usually 2–3 applications of endosulfan (0·7 kg AI/ha) to control *H. armigera*. During 1976–79, the average parasitism of small larvae was recorded at 2·8% in treated and 4% in untreated pigeonpeas and 12·1% in treated and 31·2% in untreated chickpeas (table 2).

3.4 *Other hosts of C. chlorideae*

Among the other 28 species of insect larvae that were also collected during the survey, *C. chlorideae* emerged from *H. peltigera* Schiff from safflower (6·2%, n = 5192), *Acanthospermum hispidum* DC. (1·6%, n = 2072) and *H. assulta* Guenee from *Datura metel* L. (3·2%, n = 5147), *Adisura stigmatica* Warr. from pigeonpea (3%, n = 668) and *Spodoptera litura* Fab. from groundnut (5%, n = 1032).

3.5 *Hyperparasites of C. chlorideae*

Ten species belonging to 5 families of Hymenoptera were recorded emerging from the cocoons of *C. chlorideae*. They were collected from sorghum, pearl millet, groundnut, chickpea and pigeonpea (table 3). Hyperparasitism averaged 39·1% on sorghum, 43·1% on pearl millet, 14·6% on groundnut, 9·8% on chickpea and 5% on pigeonpea. Hyperparasites *Pteromalus* spp. appeared on all these crops, but were most active on the cereals. Hyperparasites were also observed on groundnut and pigeonpea. On chickpea *Brachymeria* spp. followed by a species of *Eurytoma* were the most common hyperparasites.

Table 2. Comparison of *C. chlorideae* parasitism in *H. armigera* larvae in sprayed and unsprayed fields, ICRISAT Center, 1976–79.

	Per cent parasitism in 1–3 instar larvae			
	Pigeonpea		Chickpea	
Year	Sprayed	Unsprayed	Sprayed	Unsprayed
1976–77	2·8	4·0	14·1	26·3
	(1291)	(1001)	(972)	(350)
1977–78	4·4	4·6	11·5	28·4
	(1200)	(900)	(637)	(285)
1978–79	1·8	3·6	10·3	33·3
	(1950)	(1500)	(832)	(1212)
Mean	2·8	4·0	12·1	31·2
	(4441)	(3401)	(2441)	(1847)
SE ± (M)	0·76	0·29	1·12	2·07

Numbers in parentheses are a total number of larvae collected.

Table 3. Hyperparasites with their parasitism (%) of the cocoons of *C. chlorideae* on some crops, at ICRISAT Center, 1977–82.

	Hyperparasites	Sor-ghum	Pearl millet	Ground-nut	Pigeon pea	Chick pea
Chalcididae	*Brachymeria* sp. nr. *apantelesi* Risbec *B.* sp. (nr. *persica* Masi) *B. wittei* (Schmitz), and *Brachymeria* sp.	2·6	0·0	0·0	0·0	4·3
Eulophidae	*Nesolynx javanica* (Ferr.)	1·3	0·0	0·0	0·0	0·0
Eurytomidae	*Eurytoma* sp.	1·1	0·0	0·0	0·0	3·8
Ichneumonidae	*Hemiteles* sp.	4·8	0·0	0·0	0·0	0·7
Pteromalidae	*Pteromalus semotus* (Walker) *Pteromalus* sp., and *Eupteromalus parnarae* Gahan	29·3	43·1	14·6	5·0	0·5
Total hyperparasitism		39·1	43·1	14·6	5·0	9·8
Total cocoons collected		(1510)	(51)	(62)	(20)	(2821)

4. Discussion

C. chlorideae is the most common larval parasite among 25 insect parasites that have been recorded on *H. armigera* (Bhatnagar *et al* 1982). It is active on most of the crop and weed hosts of *H. armigera* in Andhra Pradesh, Karnataka and Maharashtra and in other parts of India on potato, cotton and lucerne (Yadhav *et al* 1982). Battu (1977) recorded a *Campoletis* sp. parasitising *S. litura* on cauliflower. *C. chlorideae* is probably capable of parasitising *H. armigera* on all of its hosts of which there are some 157 in India (Bhatnagar and Davies 1978). However, its success may vary between them.

The overall decline in the percentage parasitism by *C. chlorideae* from September to January may be attributed to the relatively higher rate of multiplication of *H. armigera* on pigeonpea and chickpea compared with other hosts during this time (Jayaraj 1981). Furthermore, the survival rate of *C. chlorideae* is lower during cooler months particularly December–January. Patel and Patel (1972) and Nikam and Basarkar (1978) showed that *C. chlorideae* suffers high pupal mortality at temperatures below 27°C and above 31°C.

The Commonwealth Institute of Entomology, London confirmed that *C. chlorideae* on *Heliothis* spp. in India was earlier misidentified as a species of *Diadegma*. P K Nikam (unpublished results) also confirmed this, and reported that the *Diadegma* spp. which have been recorded on *A. stigmatica* and *S. litura* are in fact *C. chlorideae* but not those recorded on *Exelastis atomosa* Walk. and *Perigea serva* Walk. It appears that *C. chlorideae* has a narrow host range and has preference for *H. armigera*. Pawar *et al* (1985) reported that *C. chlorideae* parasitised 22·3% (n=4147) of *H. armigera* larvae compared with 6·2% (n=5192) of *H. peltigera* larvae on safflower. This was based on a collection of both small and large larvae. This preference for *H. armigera* would certainly confer a relative advantage if large scale release of this parasite for biological control of *H. armigera* is envisaged.

C. chlorideae suffers considerable pupal mortality from hyperparasites particularly on cereals. On chickpea, the lower hyperparasite activity could be due to the acid

exudate of the plants, which is known to deter many insects from visiting this crop (Bhatnagar *et al* 1982). Hyperparasitism may be an important factor in the success of *C. chlorideae* as a biocontrol agent. A study of the factors affecting the impact of hyperparasites on *C. chlorideae* would be necessary before mass release of artificially reared *C. chlorideae* is attempted to control *H. armigera.*

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