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Insect Sci. Applic. Vol. 14, No. 4, pp. 419–426, 1993
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0191-9040/93 $3.00 + 0.00
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POPULATION DYNAMICS AND PARASITISM OF *CONIESTA (=HAIMBACHIA) IGNEFUSALIS, SESAMIA CALAMISTIS*, AND *HELIOCHEILUS ALBIPUNCTELLA* IN MILLET MONOCULTURE

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(*Received 4 February 1992; accepted 30 September 1992*)

Abstract—Studies were conducted in Niger in 1986 and 1987 on the population dynamics and parasitism of the millet stem borer, *Coniesta (=Haimbachia) ignefusalis* (Hampson) (Lepidoptera:Pyralidae), *Sesamia calamistis* Hampson, and the millet head caterpillar, *Heliocheilus albipunctella* de Joannis (Lepidoptera:Noctuidae). Planting dates were assessed for effects on population densities of *C. ignefusalis* and *H. albipunctella*. Population densities of *C. ignefusalis* were not reduced by adjusting millet planting dates, but were affected by millet growth stage. *Platytelenomus* sp. (Hymenoptera: Scelionidae) was the most common parasite of *C. ignefusalis* on millet. Parasitism of *C. ignefusalis* larvae and pupae was rare. *Sesamia calamistis* was a minor pest of millet in Niger, and was rarely parasitized. Population densities of *H. albipunctella* were reduced by delaying millet planting dates. *Bracon hebetor* (Hymenoptera: Braconidae) was the most common parasite of *H. albipunctella*.

Key Words: Population dynamics, parasitism, millet, stem borers, *Coniesta (=Haimbachia) ignefusalis, Sesamia calamistis, Heliocheilus albipunctella*, West Africa, Niger

Résumé— Des études étaient menées en 1986 et 1987 sur la dynamique et le parasitisme du foreur des tiges du mil, *Coniesta (= Haimbachia) ignefusalis* (Hampson) (Lepidoptera: Pyralidae), de *Sesamia calamistis* Hampson, et de la mineuse de l'épi du mil, *Heliocheilus albipunctella* de Joannis (Lepidoptera: Noctuidae). L'influence des dates de semis sur les densités des populations du foreur des tiges du mil, et de la mineuse de l'épi de mil a été évaluée. Les densités des populations de *C. ignefusalis* n'étaient pas réduites par l'effet des changement des dates de semis, mais étaient affectées par le stade de développement du mil. *Platytelenomus* sp. (Hymenoptera: Scelionidae) était le plus fréquent parmi les parasites de *C. ignefusalis* sur le mil. Le parasitisme des larves et chrysalides de *C. ignefusalis* était rare. *S. calamistis* n'était pas un important nuisible du mil au Niger, et était rarement parasité. Les densités des populations de la mineuse de l'épi du mil étaient réduites en retardant les dates de semis du mil. *Bracon hebetor* Say (Hymenoptera: Braconidae) était le plus fréquent parasite de la mineuse de l'épi du mil.

Mots Clés: Dynamiques des populations, parasitisme, mil, foreurs de tige, *Coniesta (=Haimbachia) ignefusalis, Sesamia calamistis, Heliocheilus albipunctella*, Afrique de l'Ouest, Niger

INTRODUCTION

Assessing the economic impact of an insect pest and developing integrated pest management strategies requires a comprehensive understanding of the insect's life history, seasonality and population dynamics (Huffaker and Smith, 1980; Hughes et al., 1984; Gutierrez and Wang, 1984; Tauber et al., 1986). Though adjusting crop planting dates should be studied as a means for limiting damage from stalk borers, the benefits of late planting must be assessed in each area

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based on the annual severity of borer attack weighed against the risk of yield reduction from delayed planting (Jepson, 1954).

The present studies were designed to describe the population dynamics and parasitism of *C. ignefusalis*, *H. albipunctella* and *S. calamistis*; determine the effect of planting date on respective population densities and assess the current pest status of *S. calamistis* on millet; and determine the relationship between millet phenological growth stages and *C. ignefusalis* population densities.

MATERIALS AND METHODS

Studies were conducted during the 1986 and 1987 millet growing seasons in Niger. Four experimental plots (two each year) were located at N'dounga, a sub-station of INRAN (Institut National de Recherches Agronomiques du Niger), Kolo Research Station. The millet variety Ex-Bornu was obtained from the ICRISAT Sahelian Centre and planted in all plots and during both years. All plots were initially planted in hills, and after emergence were thinned to three plants per hill to assure uniform plant growth. The first and second plots in 1986 were planted on 25 June and 16 July, and consisted of 26 and 15 rows, respectively. Rows were 45 m long and 80 cm apart for the first plot and 60 cm apart for second plot. The first and second plots in 1987 were planted on 3 and 30 July, and consisted of 20 rows each 45 m long, and 16 rows each 25 m long, respectively. Rows of hills were separated by 80 cm.

Destructive plant samples were taken weekly from each plot to assess the incidence of *C. ignefusalis*, *H. albipunctella*, and *S. calamistis*. Sampling in 1986 began on 20 August and 17 September for first (I) and second (II) plantings, respectively; and in 1987 began on 3 September and 24 September, respectively. A single hill was selected for sampling in each row. The hill for sampling was selected using a table of random numbers, with the random number representing the number of paces to be taken down a given row. The hill adjacent to the last pace was the hill that was sampled. The weekly sample size was 26 and 15 hills from first and second plantings in 1986, and 20 and 16 hills for first and second plantings in 1987, respectively. Each excised plant was visually inspected for the presence of stem borers and millet head caterpillar. Millet developmental stages were recorded at the time of sampling according to millet developmental stages described by Maiti and Bidinger (1981) as follows: emergence (0), three-leaf stage (1), five-leaf stage (2), panicle initiation (3), flag-leaf stage (4), boot stage (5), 50% flowering (6), milk stage (7), dough stage (8), and physiological maturity (9). Stem borer eggs were collected and held in 30 ml empty plastic cups for hatching or parasite emergence. Stalk borer pupae were removed from stalks and placed in 30 ml empty clear plastic cups. Stalk borer and *H. albipunctella* larvae were removed and held in 30 ml cups provisioned with artificial diets BIOSERV[R] mix # F9777 and mix F9782 for 1986 and 1987, respectively. Cups containing insects were held at ambient room temperature at the Kolo laboratory, and were examined daily for emergence of adult moths or parasites. Emerged parasites and associated host remains were labelled and sent to Texas A&M University, College Station, Texas for identification.

Data were analysed using an analysis of variance. Duncan's new multiple range tests (NMRT) was performed to separate means (SAS Institute, 1985a).

RESULTS AND DISCUSSION

Population dynamics and parasitism of the millet stem borer in 1986 and 1987

Mean population densities of the millet stem borer, *C. ignefusalis* per plant are shown in Fig. 1A and B for 1986, and Fig. 1C and D for 1987. The greatest mean numbers of *C. ignefusalis* eggs per plant in first planting of 1986 occurred on 27 August for eggs, 10 September for larvae, and 27 August for pupae (Fig. 1A). The greatest mean numbers of *C. ignefusalis* per plant in second planting in 1986 occurred on 1 October for eggs, 17 September for larvae, and 24 September for pupae (Fig. 1B).

In 1987, only *C. ignefusalis* larval densities are shown in Fig. 1C, as egg and pupal densities were very low. The greatest mean numbers of *C. ignefusalis* eggs per plant occurred on 15 October, and was 1.05 eggs/plant. Except for samples collected on 17 September, *C. ignefusalis* eggs were rarely observed. The greatest mean numbers of *C. ignefusalis* larvae per plant for the first planting in 1987 occurred during the first and second weeks of October (Fig. 1C). Very few pupae were collected from inspected plants, indicating a low pupal density (mean = 0.01 pupae/plant). The greatest mean numbers of *C. ignefusalis* eggs for the second planting in 1987 occurred during the second and third week of October, and for larvae during the last week of October (Fig. 1D). Pupal density in 1987 was again very low (mean = 0.01/plant).

Significantly different *C. ignefusalis* densities were not detected ($P > 0.05$) between planting dates (Table 1). Our studies give some indication that adjusting planting dates may not contribute to reduced carryover of diapausing populations of *C. ignefusalis*.

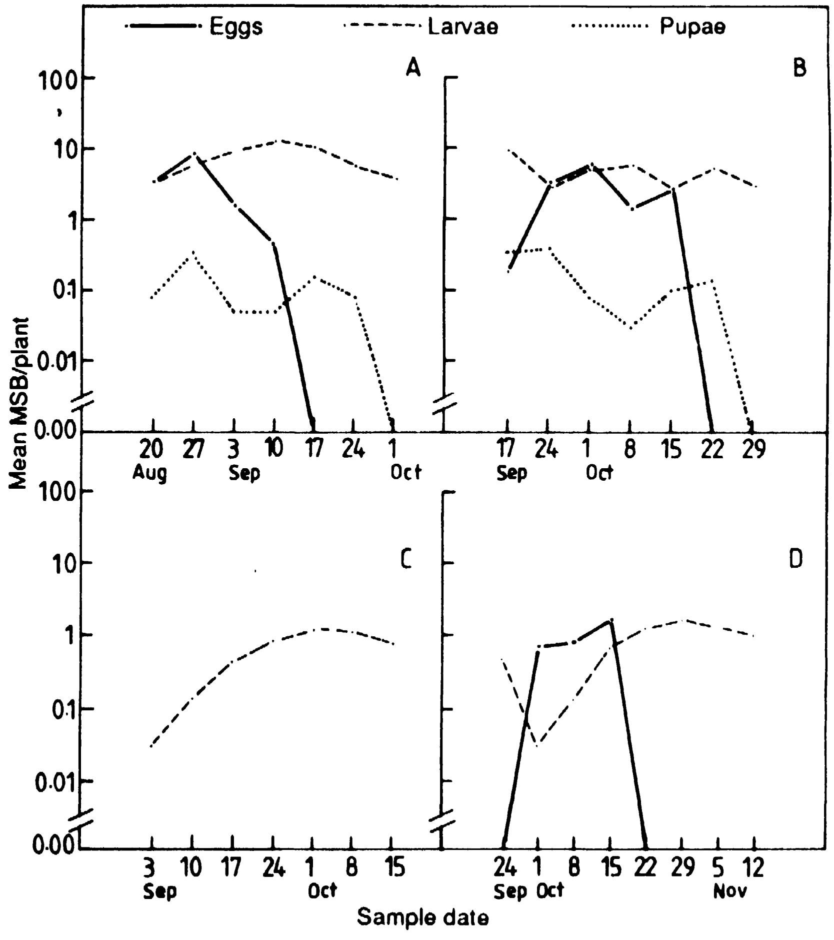

Fig. 1. Population densities of *C. ignefusalis* in 1986 for first (A) and second (B) plantings, and 1987 for first (C) and second (D) plantings.

Table 1. Mean densities of the millet stem borer per plant for two planting dates in 1986 and 1987 in Niger at N'dounga

	1986	1987	Effects of planting dates*
Plantings	Mean+	Mean+	Mean ± SE
I	9.41	0.92	5.16 ± 4.24a
II	7.07	1.30	4.18 ± 2.88a

*Means in last column followed by the same letter are not significantly different at P=0.05 (F-test).

+These values, one for each year and planting date, were used to compute overall mean *C. ignefusalis* per plant for first and second planting dates.

Mean numbers of *C. ignefusalis* per millet growth stage indicate that infestation of millet plants can begin as early as the five-leaf stage to early panicle initiation (Fig. 2). Boot and 50% flowering (half bloom) supported greater *C. ignefusalis* than other stages when data from both years and all plantings dates are combined (Fig. 2). These stages are probably more suitable for *C. ignefusalis* feeding and development. The reduction in *C. ignefusalis* population densities during dough to physiological maturity stages, is possibly due to drying of the plants. Early stages of millet, including five- through flag-leaf stages, support fewer *C. ignefusalis*. *C. ignefusalis* attack on these latter millet stages often results in premature plant death called "dead heart".

Out of the seven parasite species attacking *C. ignefusalis* on millet in 1986–87, six were identifiable and belong to the order Hymenoptera (Table 2). These parasites include the egg parasite *Platytelenomus* sp. (Scelionidae), and the larval parasites *Euvipio* sp. (Braconidae), *Rhaconotus* sp. (Braconidae), *Goniozus* sp. (Bethylidae), *Syzeuctus senegalensis* Benoit

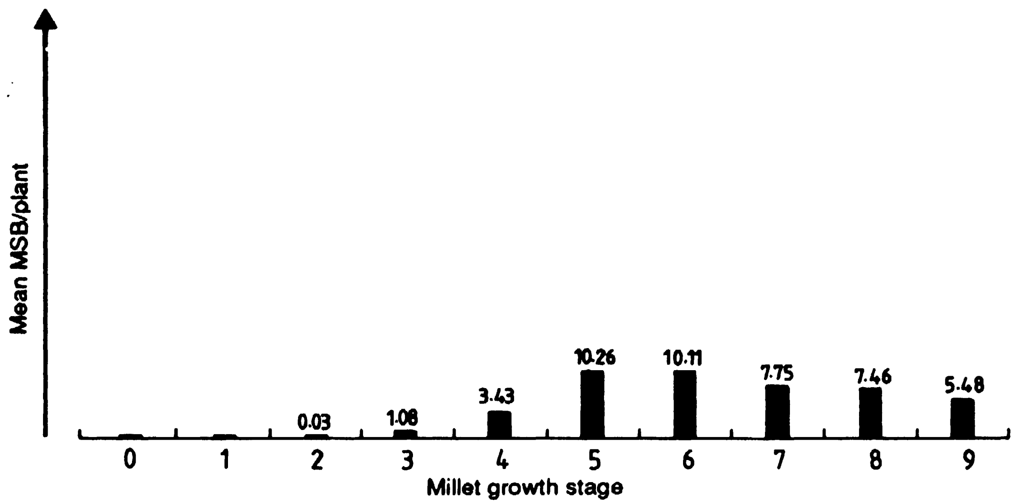

Fig. 2. Effects of millet phenological growth stage on population densities of *C. ignefusalis* for 1986 and 1987 data combined.

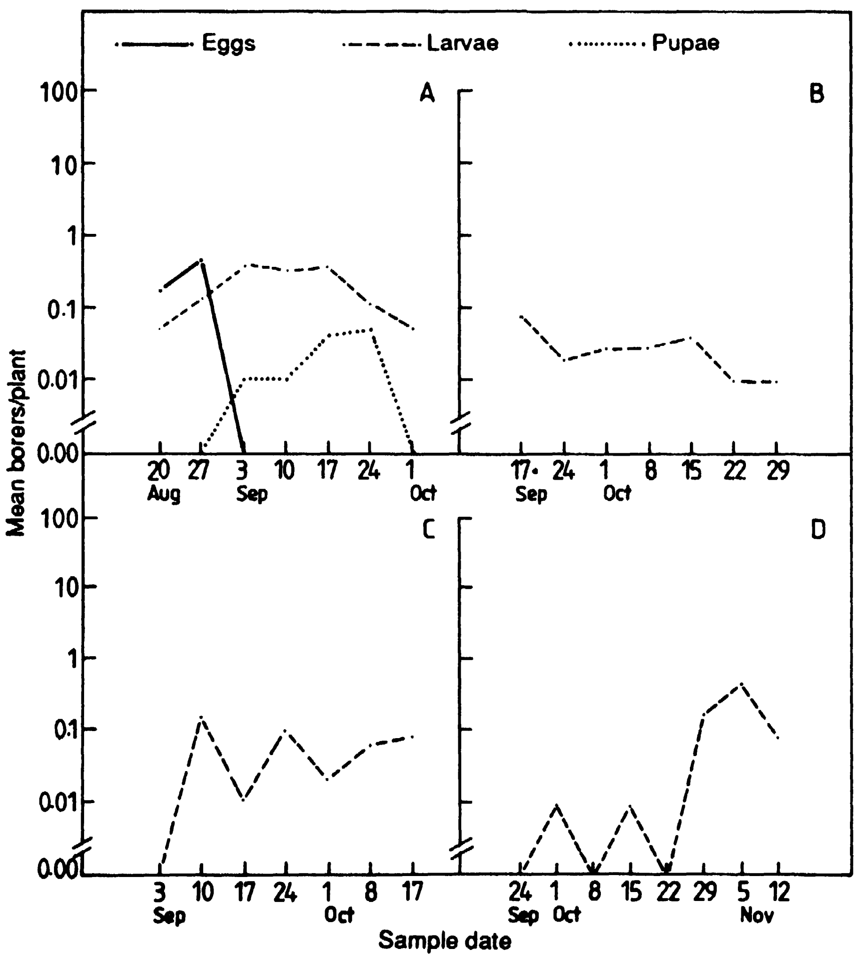

Fig. 3. Population densities of *S. calamistis* in 1986 for first (A) and second (B) plantings, and 1987 for first (C) and second (D) plantings.

Table 2. Parasitism of the millet stem borer on millet in 1986 and 1987

		Millet stem borer			Number (%) parasitized by						
Year	No. of plant samples	Stage collected	Total collected	Total parasitized	*Platytelenomus* sp.	*Euvipio* sp.	*Rhaconotus* sp.	*Goniozus* sp.	*Syzeuctus senegalensis*	*Bracon* sp.	Unidentified*
1986	2031	Eggs	4041	667	667 (16.5%)	–	–	–	–	–	–
		Larvae	13,137	42	–	21 (<1%)	1 (<1%)	8 (<1%)	9 (<1%)	1(<1%)	2 (<1%)
		Pupae	261	0	–	–	–	–	–	–	–
1987	1923	Eggs	631	43	43 (6.8%)	–	–	–	–	–	–
		Larvae	1475	9	–	0	0	5 (<1%)	2 (<1%)	0	2 (<1%)
		Pupae	3	0	–	–	–	–	–	–	–
Total both years	3954	Eggs	4672	710	710 (15.2%)	–	–	–	–	–	–
		Larvae	14,612	51	–	21 (<1%)	1 (<1%)	13 (<1%)	11(<1%)	1(<1%)	4(<1%)
		Pupae	264	0	0	–	–	–	–	–	–

*Died at immature stage.

(Ichneumonidae), and *Bracon* sp. (Braconidae). One *C. ignefusalis* larva produced an endoparasite that was in such poor condition that it was unidentifiable. Parasitism of *C. ignefusalis* eggs by *Platytelenomus* sp. was 16.5% in 1986 and 6.8% in 1987. *Platytelenomus* sp. parasitized 15.2% (710 of 4612) of all *C. ignefusalis* eggs collected in 1986 and 1987 (Table 2), and was a key source of borer mortality. Parasitism of *C. ignefusalis* larvae was very low in 1986 and 1987 (Table 2). None of the collected larval parasites exceeded 1% parasitism. When data from 1986 and 1987 are combined for all parasite species, *C. ignefusalis* larval parasitism remained at less than 1%. Out of 14,612 *C. ignefusalis* larvae collected in both 1986 and 1987, only 51 were parasitized (Table 2). *Euvipio* sp., *Goniozus* sp., and *S. senegalensis* were the most frequently collected larval parasites, accounting for 41.2, 25.5%, and 21.6% of the total, respectively. Pupal parasites were not reared from *C. ignefusalis* in either 1986 or 1987.

Previous reports of parasitism of stem borers including *C. ignefusalis* on sorghum and millet in Samaru, Nigeria (Harris, 1962), showed that parasitism by *Goniozus* sp. and *Syzeuctus* sp. seldom exceeded 10%. Results from the present studies show that *C. ignefusalis* parasitism is also low on millet. The egg parasite *Platytelenomus* sp. however, suggests some promise and could be considered a candidate for augmentative biological control. It was more common than *C. ignefusalis* larval parasites, and caused 15.2% parasitism for all eggs collected in 1986 and 1987.

Population dynamics and parasitism of S. calamistis *in 1986 and 1987*

Population densities of *S. calamistis* were generally low in 1986 and 1987 (Fig. 3). *S. calamistis* mean densities were less than one borer/plant in all sample dates and in both years, and eggs and pupae were infrequently collected. For all four plantings and both years combined, a total of 20,232 *C. ignefusalis* and *S. calamistis* eggs, larvae and pupae were collected from a total of 3954 plants dissected in all plots for both years. *C. ignefusalis* accounted for 19,548 (96.6% of all collected borer stages), whereas *S. calamistis* accounted for only 684 (3.4%). Thus, *S. calamistis* is not an important pest of millet in Niger, at least not in dry land millet.

Parasitism of *S. calamistis* was rare in 1986 and 1987. In 1986, a total of 129 eggs, 312 larvae, and 22 pupae of *S. calamistis* were collected, and these produced only one larval-pupal parasite which could be identified only as a bombyliid (Diptera). In 1987,

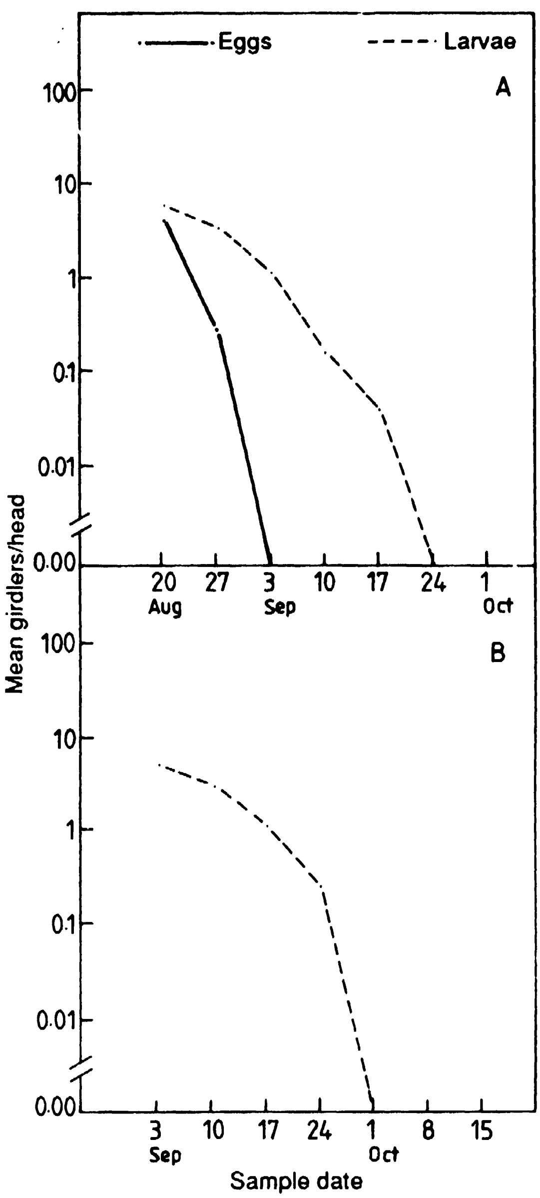

Fig. 4. Population densities of *H. albipunctella* in 1986 (A) and 1987 (B) first plantings.

a total of 62 eggs, 158 larvae, and one pupa of *S. calamistis* were collected and nohe were parasitized.

Population dynamics and parasitism of the millet head caterpillar in 1986 and 1987

Results of population dynamics studies on the millet head caterpillar, *H. albipunctella*, are shown in Fig. 4A and 4B for first plantings in 1986 and 1987, respectively. *H. albipunctella* eggs or larvae were not observed in second plantings in 1986 or 1987. *H. albipunctella* eggs occurred on 20 and 27 August for first planting in 1986, and on 3 September for 1987. *H. albipunctella* larval densities were greatest in late August (Fig. 4A) and early September (Fig. 4B) for first plantings in 1986 and 1987, respectively. *H. albipunctella* diapauses as pupae in the soil after mature larvae vacate millet heads and enter the soil, and the soil was not sampled for pupae. Guevremont (1981) reported in Maradi, Niger that the per cent *H. albipunctella* infestation of the millet variety 3/4HK was 55, 13 and 1% when planted on 10, 17, and 28 June, respectively. In the same location, *H. albipunctella* infestation of millet variety P3Kolo was 20, 2 and 0% when planted on 22 and 29 June, and 5 July, respectively (Guevremont, 1983) . Our studies generally agree with Guevremont's findings and indicate that late planted millet can escape infestation whereas, early planted millet suffers considerable attack by *H. albipunctella*. Planting millet late could reduce numbers of *H. albipunctella* by denying or reducing oviposition sites available to adults.

A total of four identified parasites attacked *H. albipunctella* on millet in 1986–1987 (Table 3). Identified parasites included *Copidosoma* sp. (egg-larval parasite, Encyrtidae), and the braconid larval parasites *Bracon hebetor* Say and *Meteorus* sp. *Copidosoma* sp. is a polyembryonic parasite which attacks *H. albipunctella* eggs, but causes mortality to

Table 3. Parasitism of the millet head caterpillar on millet in 1986 and 1987

Year	Millet head caterpillar				Number (%) parasitized by				
	No. millet head samples	Stage collected	Total collected	Total parasitized	*Copidosoma* sp.	*Bracon hebetor*	*Meteorus* sp.	*Pristomerus* sp.	Unidentified
1986	593	Eggs	277	0	–	–	–	–	–
		Larvae	763	21	0	19 (2.5%)	2 (<1%)	0	0
1987	512	Eggs	25	0	–	–	–	–	–
		Larvae	522	85	15 (3%)	60 (11.5%)	0	5 (1%)	5 (1%)
Total both years	1105	Eggs	302	0	–	–	–	–	–
		Larvae	1285	106	15 (1.2%)	79 (6%)	2 (<1%)	5 (<1%)	5 (<1%)

developing larvae. *Copidosoma* sp. caused 0 and 3% larval parasitism in 1986 and 1987, respectively; and caused 1.2% parasitism of all *H. albipunctella* larvae collected in 1986 and 1987 combined (Table 3). *B. hebetor* caused 2.5 and 11.5% larval parasitism in 1986 and 1987, respectively, and 6% parasitism of all *H. albipunctella* collected in 1986 and 1987 combined (Table 3). *Meteorus* sp., *Pristomerus* sp. (Ichneumonidae), and the unidentified larval parasites each caused less than 1% parasitism in 1986 and 1987 (Table 3). *Bracon hebetor* was the most common of all larval parasites of *H. albipunctella* both in 1986 and 1987, and parasitized 74.5% (79 of 106) of collected *H. albipunctella* larvae. In Maradi, Niger, recorded parasitism of *H. albipunctella* ranged from 9% in late August to 54% in September and *B. hebetor* accounted for 95% of parasitized larvae (Guevremont, 1982). Present studies generally agree with these findings.

In summary, the millet boot and 50% flowering growth stages were more heavily infested by *C. ignefusalis* than other stages, possibly because these stages were more suitable for oviposition and larval development. Also, larval parasitism of *C. ignefusalis* was not a major source of mortality in either planting of either 1986 or 1987. Very little larval parasitism of *C. ignefusalis* was recorded during either 1986 or 1987 population dynamics studies. The measured rates of parasitism suggest that extant larval parasites would not prevent *C. ignefusalis* from reaching damaging population levels. However, additional studies on *C. ignefusalis* parasite biology and efficacy are needed before reaching a final conclusion on parasite efficacy. Egg parasitism of *C. ignefusalis* apparently can be important, particularly parasitism from *Platytelenomus* sp. Additional work is needed to see how these parasites might perform after augmentative releases of parasite for biological control. For the *H. albipunctella* aspects of these studies, the early planted millet was heavily infested by *H. albipunctella* and late planted millet was not. *Bracon hebetor*, a larval parasite of *H. albipunctella*, was the most common parasite of all parasites collected, and should be studied further to determine its population response when augmented with laboratory produced parasites. More work is also needed on *H. albipunctella* parasites to determine the diapausing status of *H. albipunctella* in early versus late planted millet and to determine rates of parasitism for diapausing *H. albipunctella*.

Acknowledgements—Authors thank Drs. Robert Wharton and James B. Woolley and Mr. Greg Zolnerowich at the Department of Entomology, Texas A&M University, and R. W. Carlson of the Taxonomic Services Unit, USDA, Beltsville MD, for identifying stem borer and head caterpillar parasites. Thanks are also due to the Institut National de Recherches Agronomiques du Niger (INRAN) in Niger for providing research facilities, and Djibo Kondo, Nouhou Kondo and Mamadou Moussa for their technical assistance in the field. Authors also thank anonymous reviewers for their useful comments. This research was supported by the USAID Grant DSAN/XII/G-0149 through the International Sorghum/Millet Collaborative Research Support Program (INTSORMIL) and the Texas Agricultural Experiment Station (Texas A&M University System). Approved as **JA no. 1365** by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and TA no. 30824 by the Texas Agricultural Experiment Station.

REFERENCES

Guevremont H. (1981) Etude sur l'entomofaune du mil. *Rapport Annuel de Recherches Pour l'Annee 1980* (deuxieme partie). Centre National de Recherches Agronomiques (CNRA); Tarna (Maradi), Niger.

Guevremont H. (1982) Etude de la mineuse de l'epi et autres insects du mil. *Rapport Annuel de Recherches Pour l'Annee 1981*. Centre National de Recherches Agronomiques (CNRA); Tarna (Maradi), Niger.

Guevremont H. (1983) Recherches sur l'entomofaune du mil. *Rapport Annuel de Recherches Pour l'Annee 1982*. Centre National de Recherches Agronomiques (CNRA); Tarna (Maradi), Niger. 69 pp.

Gutierrez A. P. and Wang Y. H. (1984) Models for managing the economic impact of pest populations in agricultural crops. In *Ecological Entomology* (Edited by Huffaker C. B. and Rabb R. L.), pp. 729–761. Wiley, New York.

Harris K. M. (1962) Lepidopterous stemborers of cereals in Nigeria. *Bull. Entomol. Res.* 53, 139–171.

Huffaker C. B. and Smith R. F. (1980) Rationale, organization and development of a national integrated pest management project. In *New Technology of Pest Control* (Edited by Huffaker C. B.), pp. 1–24. Wiley, New York.

Hughes R. D., Jones R. E. and Gutierrez A. P. (1984) Short-term patterns of population change: the life system approach to their study. In *Ecological Entomology* (Edited by Huffaker C. B. and Rabb R. L.), pp. 309–357, Wiley, New York.

Jepson W. F. (1954) *A Critical Review of the World Literature on the Lepidopterous Stalk Borers in*

Tropical Graminaceous Crops. Commonw. Inst. Entomol., London.

Maiti R. K. and Bidinger F. R. (1981) Growth and development of the pearl millet plant. *Res. Bull.* No. 6. Patancheru, A. P., India: International Crops Research Institute for the Semi-Arid Tropics.

SAS Institute (1985a) *SAS User's Guide: Statistics*. SAS Institute, Cary, NC.

Tauber M. J., Tauber C. A. and Masaki S. (1986) *Seasonal Adaptations of Insects*. Oxford, New York.