Beneficial role of corn leaf aphid, *Rhopalosiphum maidis* (Fitch) (Homoptera: Aphididae), in maintaining *Hippodamia* spp. (Coleoptera: Coccinellidae) in grain sorghum

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ABSTRACT. The significance of corn leaf aphid, *Rhopalosiphum maidis* (Fitch), as a food source for the natural enemies of greenbug, *Schizaphis graminum* (Rondani), was determined in the Texas High Plains sorghum agroecosystem. The most abundant coccinellid species were *Hippodamia convergens* (Guerin-Meneville) and *H. sinuata* (Mulsant). Neither coccinellid species showed any preference for either greenbug or corn leaf aphid in replicated choice predation tests. Corn leaf aphid and coccinellid densities increased at similar rates in the early season during both 1982 and 1983. Regression analyses suggested that variation in corn leaf aphid and greenbug densities significantly contribute to the variation in coccinellid densities. Furthermore, corn leaf aphid and coccinellid densities were significantly and positively correlated prior to sorghum panicle emergence. However, after panicle emergence only greenbug and coccinellid densities were highly correlated, reflecting a change in coccinellid food source from primarily corn leaf aphids to greenbugs. The ability of coccinellids to regulate greenbug densities may be largely dependent on the abundance of corn leaf aphids as a food source during early season crop growth.

Introduction

The greenbug, *Schizaphis graminum* (Rondani), and the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), are the most common aphids found in grain sorghum in the United States (Young and Teetes, 1977). The greenbug (GB) frequently causes significant economic damage to sorghum. The corn leaf aphid (CLA) often reaches very high densities in the whorl of grain sorghum during vegetative growth stages, but rarely causes economic damage (Teetes, 1979). Numerous parasitic and predatory natural enemies attack both aphid species in wheat/sorghum agroecosystems. The parasites *Lysiphlebus testaceipes* (Cresson) and *Aphelinus varipes* (Foerster) are frequently collected from both aphid species (Jackson *et al.*, 1970; Walker, Bottrell and Cate, 1973; Archer *et al.*, 1974; Teetes, Lopez and Schaefer, 1975; Gilstrap, Brooks and Kring, 1984). Predacious coccinellids e.g. *Hippodamia convergens* (Guerin-Meneville), *H. sinuata* (Mulsant), chrysopids, hemerobiids, syrphids and anthocorids are the most active and abundant predators in grain sorghum (Young and Teetes, 1977; Kring and Gilstrap, 1984). It has been established that the coccinellids *H. convergens* and *H. sinuata* can be responsible for the natural control of GB in Texas High Plains sorghum (Kring and Gilstrap, 1984; Kring, Gilstrap and Michels, 1985).

Several reports note the lack of significant natural enemy activity at various periods of the sorghum-growing season, and attribute GB outbreaks to the absence of these natural controls (Dahms, 1973; Teetes *et al.*, 1975; Wallin and Loonan, 1977). GB does not usually attain high densities in High Plains sorghum until panicle emergence, whereas CLA often is common from the seedling to boot stages of sorghum development. The early season concurrence of natural enemies and high CLA densities (relative to GB) in grain sorghum suggests that CLA is an important alternate prey to the GB enemies (Teetes *et al.*, 1975; Young and Teetes, 1977).

The experiments described in this paper were designed to determine the importance of CLA as a host to the GB natural enemies, particularly the coccinellids. It has been determined that the presence of aphid hosts is required in the early season to bring coccinellids to the field and to prevent their dispersal (Hodek,

1973). These experiments also investigated whether a preference for either aphid species is exhibited in the laboratory by the predominant coccinellids, *H. convergens* and *H. sinuata*.

Materials and methods

Field studies

The experiments were conducted using grain sorghum in a 1 ha plot at the Bushland field station of the Texas Agricultural Experiment Station near Amarillo. Agronomic management of grain sorghum paralleled that of High Plains commercial sorghum production, except that no insecticides were applied. The grain sorghum hybrid planted on 27 May 1982 and 1 June 1983 was AT×399×T×430. Furrow irrigation was applied as needed.

Data were collected on the temporal abundance of GB, CLA and beneficial insects using exclusion methodologies designed to evaluate the efficacy of the natural enemies of grain sorghum aphid (Kring and Gilstrap, 1984; Kring *et al.*, 1985). Data from non-exclusion cages only are treated herein. Two types of cages were used for the experiment: (1) cylindrical cages covering one whole plant, and (2) large cages covering about 30 plants; these cages are hereafter referred to as 'single plant' (SP) and 'multiple plant' (MP) cages, respectively. The cages were placed at regular intervals in a diagonal line across the field. SP cages were used from the seedling stage to the 8-leaf stage of sorghum development, when aphids are generally less numerous and a greater number of samples is required. MP cages were monitored throughout the season.

SP cages were constructed from white plastic buckets each 19 litres in capacity and 30 cm in diameter. Each bucket had four openings (each 15 cm×15 cm) on the sides. The opening orientated towards the prevailing wind was covered with fine saran Lumite® mesh (21 cells/cm); the other three were left uncovered. Bucket bottoms were removed and also covered with saran. Buckets were then inverted and placed over a randomly chosen grain sorghum seedling. Fifteen SP cages were used at two separate intervals each year.

MP cages (1·8 m×1·8 m×1·2 m) were placed over two rows of newly planted grain sorghum. The cages were constructed of saran Lumite suspended by conduit frames 2·5 cm in diameter. The cages were erected with a 30 cm opening between the ground and the entire lower perimeter edge of each cage. Four of these cages were erected diagonally across the field each year. Five plants in each cage were chosen at random and marked after seedling emergence. These plants were used to monitor insect abundance in the cages throughout the season.

Each caged plant was infested with two adult GB shortly after seedling emergence. By the 'open' cage design, naturally occurring GB and CLA were able to move on to the caged plants through the openings. Numbers of live aphids, parasitized aphids (mummies) and predators (adult and larval) were recorded on alternate days in SP cages and twice weekly in MP cages. Because of mobility, predator densities in MP cages were recorded as a class value (0 = 0 predators visible; 1 = 1–5 predators; 2 = 6–10, etc.) per cage for each predator species. Plant growth stage according to the system reported by Vanderlip (1972) was also recorded on each census date.

Laboratory studies

A choice-test feeding experiment without replacement was conducted to determine preference of the coccinellid species for GB or CLA. Ten GB and 10 CLA of mixed instars were placed in the same Petri dish (100 mm×15 mm) with moistened filter paper with one coccinellid adult (either *H. convergens* or *H. sinuata*). The experiment was replicated 10 times on five different occasions for each coccinellid species. The number of aphids of each species was recorded hourly until one aphid species was eliminated by predation. Coccinellids were maintained on equal ratios of GB and CLA during non-test periods. An index of preference, β, as reported by Manly, Miller and Cook (1972), was calculated for each predator. The index is based on the ratio of proportionate mortalities of the two aphid species expressed in natural logarithms.

Results and discussion

Field studies

CLA was the most common aphid in grain sorghum until after the boot stage of sorghum development and was usually found in the whorl. GB occurred on lower leaf surfaces and remained at low densities until the pre-boot or flag leaf stage (Figure 1). Parasite densities remained low (<1 per plant) until late in the season, at the milk and soft dough stages of plant development. Parasite densities peaked at approximately 70/plant (about 35% parasitism) at the hard dough stage of sorghum development. At this stage about 75% of the grain dry weight has accumulated and nutrient uptake is essentially complete (Vanderlip, 1972). Coccinellids were the most abundant predacious species, representing at least 85% of all predators collected on any census date. Coccinellid densities increased concurrent with CLA density increase. After the boot stage, coccinellid densities continued to increase as GB densities increased and CLA densities declined. The general decline in CLA densities during both years coincided with the exertion of the panicle from the whorl, reflecting CLA's preferred feeding location in the whorl. CLA was the dominant predator food source in the early season, maintaining these enemies at
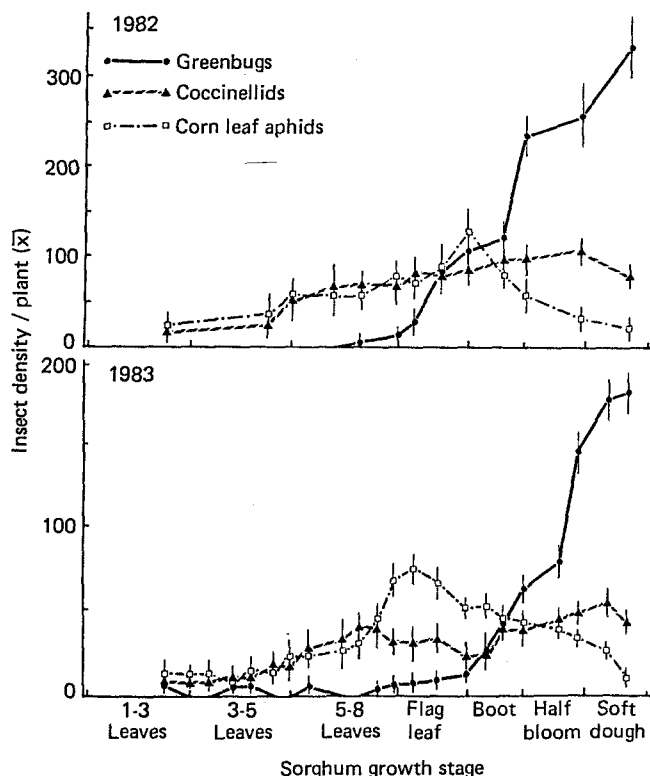
FIGURE 1. Comparison of greenbug, corn leaf aphid and coccinellid densities (±SE) on caged sorghum plants accessible to natural enemies during 1982 and 1983 at Bushland, Texas.

relatively high densities. GB densities increased at the end of the growing season, but did not exceed established economic threshold levels either year.

Regression of combined coccinellid densities on to CLA densities and GB densities indicated that variation in both aphid densities significantly contributed to the variation in coccinellid density during both years ($P=0\cdot0006$, $r=0\cdot92$). Spearman's rank correlation coefficient (r_s) was calculated for the aphid and coccinellid densities. There was a highly significant ($P=0\cdot01$) positive correlation between CLA and coccinellid densities during the vegetative stages of growth, prior to boot development (1982: $r_s=0\cdot85$; 1983: $r_s=0\cdot81$). Correlations between GB and coccinellid densities were not significant during this period. However, after the boot stage of development GB and coccinellid densities were significantly ($P=0\cdot05$) and positively correlated (1982: $r_s=-1\cdot0$; 1983: $r_s=0\cdot79$, whereas CLA and coccinellid densities were significantly and negatively correlated (1982: $r_s=-1\cdot0$; 1983: $r_s=-0\cdot75$). These relationships probably reflect the change in coccinellid prey from CLA to GB after the boot stage of plant development. These analyses substantiate the importance of CLA in maintaining high coccinellid densities until GB densities increase later in the season.

Laboratory studies

There was no significant difference in the numbers of CLA or GB consumed by either coccinellid species in

TABLE 1. Choice test of *H. convergens* and *H. sinuata* for *S. graminum* and *R. maidis*

| Coccinellid species | Interval (HPI)* | Mean number consumed in interval ± SE** | | Mean preference index†±SE |
		S. graminum	*R. maidis*	
H. convergens	0	0	0	
	2	4·0 ± 0·11	4·2 ± 0·14	
	4	3·3 ± 0·10	3·4 ± 0·11	
	6	1·5 ± 0·15	1·2 ± 0·13	0·506 ± 0·036
	8	2·1 ± 0·10	2·0 ± 0·12	
	10	1·1 ± 0·20	0·8 ± 0·31	
	12	0·1 ± 0·40	0·2 ± 0·39	
H. sinuata	0	0	0	
	2	4·3 ± 0·09	4·1 ± 0·18	
	4	3·4 ± 0·14	3·4 ± 0·10	
	6	1·3 ± 0·16	1·4 ± 0·13	0·500 ± 0·010
	8	1·9 ± 0·22	2·1 ± 0·21	
	10	1·2 ± 0·17	1·1 ± 0·12	
	12	0	0·1 ± 0·43	

* Hours Post Initiation.

** Mean number eaten not significantly different ($P=0\cdot05$) in any interval (t-test).

$\dagger \beta= \dfrac{1}{1 + \dfrac{ln(N'_E/N')}{ln(N_E/N)}}$: the probability that the next prey eaten is a greenbug (prey type I).

N_E, N'_E = Number of prey type I and type II eaten (respectively).

N, N' = Number of prey type I and type II initially present.

the choice test (Table 1). Such a laboratory study ignores possible habitat preference by either predator species, as no attempt was made to reconstruct the plant whorl, where CLA is most commonly found. Field observations indicate that both coccinellid species were active in the whorl as well as on lower leaf surfaces. Exhibition of a preference for either aphid species by the coccinellids was also determined by calculating a preference index (β). Several indices of preference assume that relative prey densities remain constant for the duration of an experiment (Cock, 1978). However, because prey in the present experiment were not replaced as they were consumed, the relative densities of the prey types and the probabilities of contact changed through time. Manly et al. (1972) reported that the index β takes into account the depletion of prey density as each trial progresses. Accounting for depletion of prey makes β the only suitable index for this type of experiment. A value of $0 \cdot 5$ for β indicates no preference by a predator for a prey type. The mean index values were $0 \cdot 506$ and $0 \cdot 500$ for *H. convergens* and *H. sinuata*, respectively. These values are not significantly different (t-test, $P = 0 \cdot 05$) from $0 \cdot 5$, thus indicating no preference. This lack of preference for either GB or CLA by the predators would suggest a smooth transition of these predators from CLA to GB as a primary food source as the season progresses.

Corn leaf aphid can be an important factor in the sorghum pest management system, judged by applications of insecticides to control the insect (Teetes, 1979). Chemical treatments for CLA based on fear of economic damage or taxonomic confusion with GB will probably disrupt natural GB controls later in the season. These experiments suggested that CLA has a key role in maintaining high densities of predacious coccinellids, which are important GB natural enemies (Kring *et al.*, 1985). This beneficial role of CLA should be given serious consideration before insecticide applications for CLA in grain sorghum.

Notes and acknowledgements

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