PARASITES COLLECTED FROM GREENBUGS AND CORN LEAF APHIDS IN KANSAS AND BIOLOGICAL STUDIES ON PACHYNEURON SIPHONOPHORAE (ASHMEAD)

by

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A MASTER'S THESIS

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requirements for the degree

MASTER OF SCIENCE

Crop Protection

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INTRODUCTION

The greenbug, Schizaphis graminum (Rondani) is a serious pest of sorghum and small grains throughout the Great Plains region. It was described in Italy in 1852 (Hunter and Glenn, 1909) and first reported in the United States as early as 1882 in Virginia (Webster and Phillips, 1912). Outbreaks have occurred on small grains in 1890, 1901, 1907, 1916, 1939, 1942, and 1949-51 (Daniels et al., 1956). It was first reported in Kansas in 1907, having spread northward from Texas (Hunter and Glenn, 1909).

Passerini first recorded sorghum as a host plant for the greenbug in 1863 (Webster and Phillips, 1912), but no severe damage was reported to that crop until 1968 when record losses occurred in Arizona, California, Colorado, Kansas, New Mexico, Nebraska, Oklahoma, South Dakota, and Texas (Wood et al., 1969, Harvey and Hackerott, 1969a). Greenbugs able to survive on sorghum as well as small grains are considered a distinct biotype, different than those attacking only small grains, and are disignated biotype C (Harvey and Hackerott, 1969b).

Lysiphlebus testaceipes (Cresson), a braconid wasp, serves as a major means of natural control of the greenbug (Hunter and Glenn, 1909) and is present to a greater or lesser degree wherever the greenbug occurs (Webster and Phillips, 1912). It readily attacks all instars of the

greenbug (Hight et al., 1972), including newborn aphids (Ruth et al., 1974).

Surveys conducted in Oklahoma (Jackson et al., 1973, Archer et al., 1974) and Texas (Walker et al., 1973) have revealed that L. testaceipes is only one of many hymenopterous insects involved in a parasite complex of which the greenbug is host. Three primary parasites and four secondary parasites are involved. Each survey showed L. testaceipes to be the most abundant primary parasite of the greenbug. Jackson et al., (1970) reported that Aphidencyrtus aphidivorus (Mayr) was the most abundant secondary parasite. In a second survey by Jackson et al., (1971) in central Oklahoma and in the surveys of Archer et al., (1974) and Walker et al., (1973) the most abundant secondary parasite of the greenbug was Pachyneuron siphonophorae (Ashmead). Secondary parasites were responsible for reducing the numbers of primary parasites therby reducing the benefit of natural enemies of the greenbug.

The ability of secondary parasites to interrupt the control afforded by primary parasites is an important factor in pest management. The literature reveals that early observers such as Folsom and Bondy (1930) mistakenly concluded that secondary parasites such as P. siphonophorae were beneficial in destroying aphids because they were observed emerging from the aphid mummy. Conclusions drawn from studies conducted in the high plains of Texas (Walker

et al., 1973) and reaffirmed by the Oklahoma surveys, are that secondary parasitism occurs at significant levels and reduces the effectiveness of primary parasites. Archer et al., (1974) reemphasizes the suggestion of Walker et al., (1973) that further investigation of these secondary parasites be conducted to determine their role in the dynamics of greenbug populations. Very little information exists in the literature on the subject and few secondary parasites have been studied in detail. P. siphonophorae is often mentioned as an aphid parasite, but no specific work has been conducted into its biology.

The purpose of this study was (1) to determine the species of hymenopterous parasites of the greenbug and corn leaf aphids in Kansas and (2) to determine the development time and host-age acceptability of P. siphonophorae, found to be the most abundant secondary parasite in past surveys.

MATERIALS AND METHODS

Survey.

A survey was conducted to determine the species of hymenoptorous parasites attacking greenbugs and corn leaf aphids in the major sorghum producing areas of Kansas in 1978. The areas included in the survey were sampled throughout the period between June 1 and September 15. Many locations had very low to nonexistent populations of greenbugs in June and the first part of July. The survey concentrated in areas where greenbug and/or corn leaf aphid infestations were substantial.

Figure 1 shows the counties from which fields were sampled. The fields sampled were planted, fertilized, cultivated and harvested according to agronomic practices customarily employed in the area. Fields were surveyed by randomly selecting four locations and sampling 25 plants in a row.

Mummies were collected by using a paper punch to punch out small circular pieces of the sorghum leaf to which aphid mummies were attached. The small leaf discs and mummies were caught in a retainer clip as they were removed from the leaf. Mummies were transfered to a glass vial and labeled as to date and field sampled. In the lab, the mummies were placed singly in 1 dram glass vials and held

at 26.7°C and 65 percent RH for emergence. Following emergence, the aphid host and parasite were identified and recorded. Parasites were identified according to the key developed by Johnson (1978).

While in the field, notes were taken on (1) stage of plant development, (2) level of damage due to greenbug infestation, (3) average number of greenbugs per plant, (4) other aphidiphagous insects, and (5) level of parasitism.

Biological studies.

Studies involving P. siphonophorae were conducted in the laboratory using field-collected specimens as stock. Insects were reared on greenbug-infested sorghum grown in pots and held in 2' x 2' x 2' cages in the greenhouse.

Developmental period. To determine developmental period of P. siphonophorae, greenbugs were caged on seedling sorghum, grown singly in 3" plastic pots caged by 6" clear, plastic cups. Ten plants with 10 greenbugs per plant were exposed to mated female L. testaceipes. Seven days later the mummies were exposed to mated, female P. siphonophorae adults for a period of eight hours. After removing the adult parasites, the caged plants were held in a growth chamber at 24°C and watched until the secondary

parasites emerged. Each emerging parasite was identified and the day of emergence recorded.

Host acceptability. Studies of host-age acceptance were conducted using the same caged-plant technique used for the development work. Greenbugs varying in age of exposure to L. testaceipes from five to eleven days were exposed to mated P. siphonophorae females for a period of eight hours. Following secondary parasitism the mummies were held at 24°C and parasite emergence was recorded.

Notes on behavior. While biological studies on the developmental period and host acceptability of P. siphonophorae were conducted, notes on the behavior of the insect were also recorded.

Mating, mummy inspection, construction of the feeding tube, host-feeding, and egg-laying were observed.

RESULTS

Survey.

Six species of hymenopterous parasites representing five families were found to be a part of the parasite complex affecting aphid populations in Kansas during 1978. Table 1 lists periods of collection, number of parasitized aphids collected, number of parasites emerging and species of both primary and secondary parasites. Table 2 gives the percentages of primary and secondary parasites emerging from mummies collected during each separate period. Figures 2 and 3 show the number of primary and secondary parasites collected on each sampling date for the southwest region and northern region respectively. Figures 4 and 5 illustrate the percent of primary and secondary parasites which comprised the total number of parasites emerging on each sampling date.

The most abundant primary parasite was the braconid, L. testaceipes. It accounted for 96 percent of the primary parasites collected and 41 percent of all parasites. The only other primary parasite collected was Aphelinus nigritus Howard. These two primary parasites were distinguishable in the field on the basis of mummy color. Aphids parasitized by L. testaceipes turn gold in color, while those parasitized

by A. nigritus turn black. Seventy-five percent of A. nigritus collected came from western areas of the state. Only P. siphonophorae and A. aphidivorus species were collected from A. nigritus mummies.

The most abundant secondary parasite was the pteromalid, P. siphonophorae. It represented over half of the parasites collected in the latter half of August and the first two weeks in September. Over the period of time the survey was conducted the secondary parasite, P. siphonophorae, displaced the primary parasite, L. testaceipes, as the most abundant parasite in the field.

The second most abundant secondary parasite collected was Charips sp. This cynipid parasite was prevalent in substantial numbers throughout the growing season. In addition, adults of Charips sp. were collected from wheat fields in the spring prior to the survey on sorghum. Also recovered in the survey were the pteromalid, Asaphes lucens (Provancher), and the encyrtid, A. aphidivorus. Both species were collected in far lesser numbers than Charips sp. or P. siphonophorae.

Biological studies.

Investigations into the biology of the secondary parasite P. siphonophorae revealed information useful in

further understanding the effect of this insect in the aphid-parasite-secondary parasite ecosystem.

Developmental period. The results of the investigation into the length of development of P. siphonophorae are given in Table 3. Of the 55 parasites emerging in the test, 65 percent emerged during the tenth day, 33 percent during the eleventh day, and the remainder the twelfth day. Of the total number of aphid mummies parasitized by secondary parasites, 89 percent produced P. siphonophorae adults and 11 percent L. testaceipes.

Host acceptability. Results of the host acceptability test are given in Table 4. All ages of aphid mummies tested served as acceptable hosts for P. siphonophorae. The range of percent emergence was from 20 percent for the five day old age group to 100 percent for the nine day old age group. Of the mummies aged ten days, only three were parasitized by P. siphonophorae, and the rest produced adult L. testaceipes the following day.

Notes on behavior. Mating was observed on several occasions. In each instance the male chased the female while his wings were held raised and beating. At some point in time, the eligible female stopped and the male quickly mounted onto her dorsal side. From this position, copulation ensued, with the male continuing to beat his wings while holding them in the raised position. The

females were motionless during the mating process. Both males and females were observed to take part in the mating process more than one time.

Ovipositional behavior of P. siphonophorae involved mummy inspection, creation of the feeding tube, host-feeding, and oviposition similar to that of A. lucens (Sullivan, 1976).

During the initial approach to the mummy, P. siphonophorae palpated the surface of the parasitized aphid on the top and sides. In the event of an empty mummy, the parasite quickly lost interest. If, however, the mummy was recognized as suitable, the parasite climbed upon it. Atop the parasitized aphid, P. siphonophorae carefully inserted its ovipositor roughly near the center of the mummies dorsal side. The ovipositor was moved in a circular motion while being inserted and withdrawn, and a feeding tube was constructed. Fluids within the pupating primary parasite rose up through the feeding tube by capillary action. The parasite then turned around and fed for a period of 20-40 minutes at times leaving the mummy, but returning to it. After feeding, P. siphonophorae reinserted the ovipositor for actual oviposition. The parasite was then believed to have destroyed the feeding tube to "seal" the developing primary parasite pupae which had just received the P. siphonophorae egg.

DISCUSSION

Survey.

L. testaceipes was found to be the most abundant primary parasite on aphids in sorghum in Kansas during 1978. In June it was scarce due to few greenbugs and in July most collections were made from corn leaf aphids. Numbers of L. testaceipes were quite high during the first collection period in August, but then were reduced steadily by increased recovery of secondary parasites. The other primary parasite recovered was A. nigritus.

The most abundant secondary parasite was P. siphonophorae. This is in agreement with Archer et al. (1974), but in contrast to Jackson et al. (1970). P. siphonophorae gradually replaced L. testaceipes as the most prevalent parasite. It emerged from both black and gold mummies indicating it can act as a secondary parasite on both L. testaceipes and A. nigritus. In 1969, Jackson et al. (1970) reported A. aphidivorus to be the most prevalent secondary parasite. In a survey in 1970 in central Oklahoma, Jackson et al. (1971) reported P. siphonophorae to be the most abundant secondary parasite on greenbugs and corn leaf aphids in sorghum, indicating a relative increase in the parasite.

A. lucens was collected from eleven locations and was

the third most abundant secondary parasite recovered. This varies considerably with the surveys of Jackson et al. (1970) and Archer et al. (1974), each of whom recorded only a single specimen.

Very few secondary parasites were reared from samples collected in the western areas of the state until September. Aphids were not as numerous there early in the season as in eastern portions of the state and is seen as a contributing factor. The comparisons described in Figures 2 and 3 show the density-dependent relationship existing between the primary and secondary parasites. The population of secondary parasites is delayed from a similar population of primary parasites.

Large predator populations present during June and July were responsible for suppressing greenbugs and corn leaf aphids in sorghum fields. The main predators involved in controlling early-season aphid populations were Hippodamia convergens Guerrin-Meneville (Coleoptera: Coccinellidae) and members of the families Chrysopidae (Neuroptera) and Syrphidae (Diptera).

Nineteen counties were surveyed. A few counties had no aphid infestations in the checked fields. Aphids and parasites likely were present but in such low numbers as not to be detected. This should not be viewed as an absence of aphid or parasite activity.

Biological studies.

Developmental period. The time of development of P. siphonophorae from egg to adult averaged 10.4 days. The time required for development ranged from 10 to 12 days. This time is very close to the development time of egg to adult determined for L. testaceipes at a similar temperature by Hight et al. (1972).

Host acceptability. This work points out the ability of P. siphonophorae to parasitize all pupal stages including the pre-pupal stage, resulting in emergence of adult secondary parasites. Although restricted to mummified forms of the parasitized aphid, no specific age of mummified aphid is necessary for oviposition to occur.

Notes on behavior. Results from the biological studies and observations suggest P. siphonophorae spends considerably more time in ovipositing in an individual than L. testaceipes. A single L. testaceipes is capable of parasitizing over 250 individuals (Sekhar, 1957). Based on observations, it is doubtful that P. siphonophorae would have such capability. As a result of this difference in behavior, one might deduce that L. testaceipes is capable of parasitizing more individuals in a given period of time than P. siphonophorae. Providing an adequately large populations of aphids, L. testaceipes could continue to

increase in numbers while experiencing a fairly high degree of secondary parasitization.

The feeding behavior of P. siphonophorae is more time consuming than L. testaceipes which feeds on honeydew excreted by aphids. P. siphonophorae feeds upon the host pupa following construction of the feeding tube and prior to oviposition. In instances where no feeding occurred, several minutes were required to mount the mummy, insert the ovipositor into the mummy and search for the host pupa.

P. siphonophorae does not appear to possess the flying capabilities of L. testaceipes. P. siphonophorae was observed in the field and laboratory to fly only short distances and much of its travel around the plant was by walking and jumping.

Knipling and Gilmore (1971) state that two factors important in determining the level of parasitism a population of parasites might achieve are host-finding efficiency and egg-laying-ability. Their conclusions are that moderately high aphid populations must be available before parasites can increase to levels that will achieve high rates of parasitism. Through observation it is clear that L. testaceipes has a distinct advantage in each case. However, low populations of aphids will reduce these advantages and result in a higher percent of secondary parasitism. When moderately high numbers of aphids are present

L. testaceipes is able to continue to parasitize more aphids than P. siphonophorae can parasitize mummies, and the former will not be displaced. Sullivan and van den Bosch (1971) indicate that while the aphid parasite ecosystem is stable, high degrees of secondary parasitism can be tolerated without displacement of the primary parasite population. The findings of this study are in agreement with the aforementioned study, as L. testaceipes effected control over the greenbug in the latter half of August while experiencing high levels of secondary parasitism.

SUMMARY

L. testaceipes was the most abundant parasite of greenbugs and corn leaf aphids on grain sorghum in Kansas during 1978. *P. siphonophorae* was the most abundant secondary parasite, and was found parasitizing both *L. testaceipes* and *A. nigritum*. The incidence of secondary parasitism steadily increased during the survey. In the latter half of August, secondary parasites accounted for 75 percent of the parasites emerging from parasitized aphids collected. Secondary parasitism is believed to have had a more pronounced affect on the natural control afforded by primary parasites because of low populations of aphids throughout most of the season.

The level of aphid infestation is a critical factor in light of the differences between *L. testaceipes* and *P. siphonophorae* in terms of time spent in each oviposotional act and feeding behavior.

The developmental period of *P. siphonophorae* was determined to be 10.4 days with a range of 10 to 12 days.

All pupal stages, including the pre-pupal stage, of *L. testaceipes* were acceptable as hosts to *P. siphonophorae*.

Important notes on the behavior of *P. siphonophorae* include host-feeding and the amount of time spent in that process before oviposition is complete.

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Table 1. Parasites emerging form greenbugs and corn leaf aphids collected from grain sorghum in Kansas during 1978.

Periods of collection	Number of mummies collected	Number of parasites emerging	Number of emerging parasites of each species					
			Primary parasites			Secondary parasites		
			L. testaceipes	A. nigritus	P. siphonophorae	A. aphidivorus	A. lucens	Charips sp.
July 16 - 31	264	145	87	5	12	6	5	30
August 1 - 15	1348	1079	595	26	212	29	104	113
August 16-31	1187	902	216	10	478	8	38	152
September 1-15	159	118	24	0	24	0	0	20

Table 2. Percentage of parasites emerging from greenbugs and corn leaf aphids collected from grain sorghum in Kansas during 1978.

Periods of collection	Number of mummies collected	Percentage of parasites emerged	Percentage of emerging parasites of each species					
			Primary parasites		Secondary parasites			
			L. testaceipes	A. nigritus	P. siphonophorae	A. aphidivorus	A. lucens	Charips sp.
July 16-31	264	55	60	3	8	4	3	21
August 1-15	1348	80	55	2	20	3	10	10
August 16-31	1187	76	24	1	53	1	4	17
September 1-15	159	74	20	0	63	0	0	17

Table 3. Developmental period of P. siphonophorae.

Number Available Mummies	Percent Parasites Emerging	Parasites Emerging in Days:		
		10	11	12
62	89	36	18	1

Table 4. Host Acceptability to L. siphonophorae.

Host Age (days)	Number of Mummies Exposed	Number of Secondary Parasites Emerged
10	8	3*
9	8	8
8	10	5
7	9	7
6	10	9
5	10**	2

* Five L. testaceipes emerged from the remainder of the mummies in this age group.

** All mummies contained last instar larvae at the start of the test period.

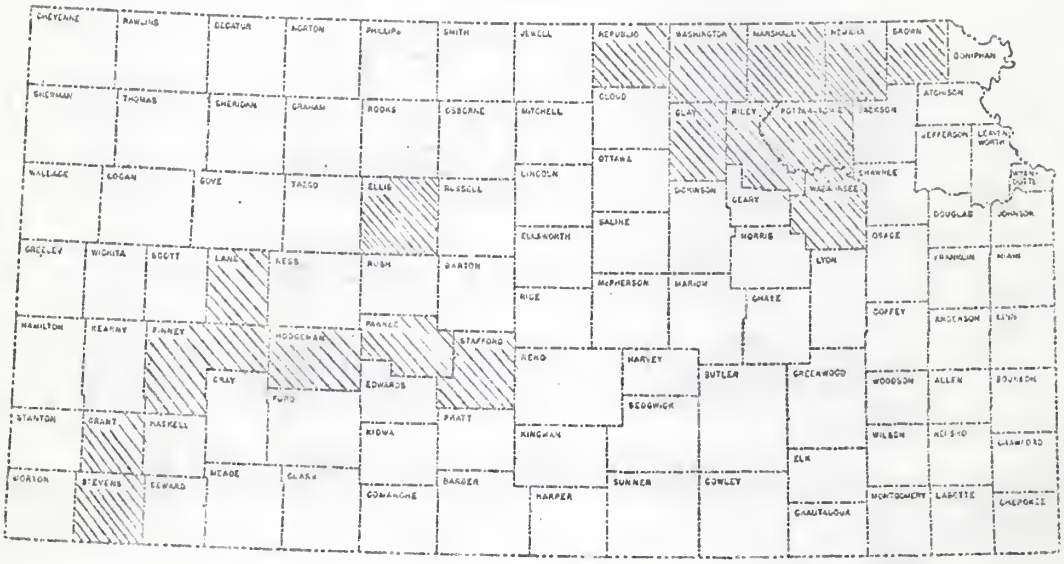


Figure 1. - Counties surveyed for parasites of greenbugs and corn leaf aphids in Kansas in 1978.

Fig. 2. The number of primary and secondary parasites collected from greenbugs and corn leaf aphids in the southwest region of Kansas.

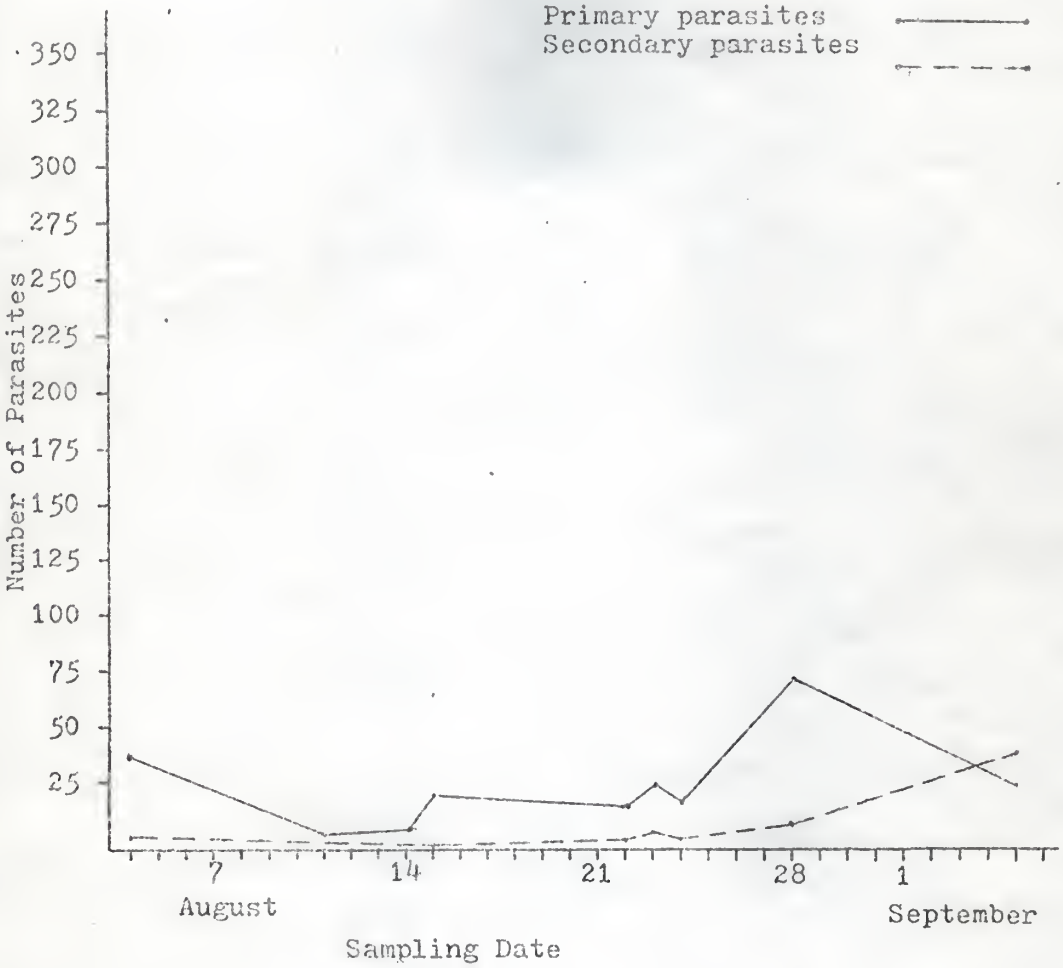

Primary parasites
Secondary parasites
350
325
300
275
250
225
200
175
150
125
100
75
50
25
Number of Parasites
7
14
21
28
1
August
September
Sampling Date

Fig. 3. The number of primary and secondary parasites collected from greenbugs and corn leaf aphids in the northeast region of Kansas.

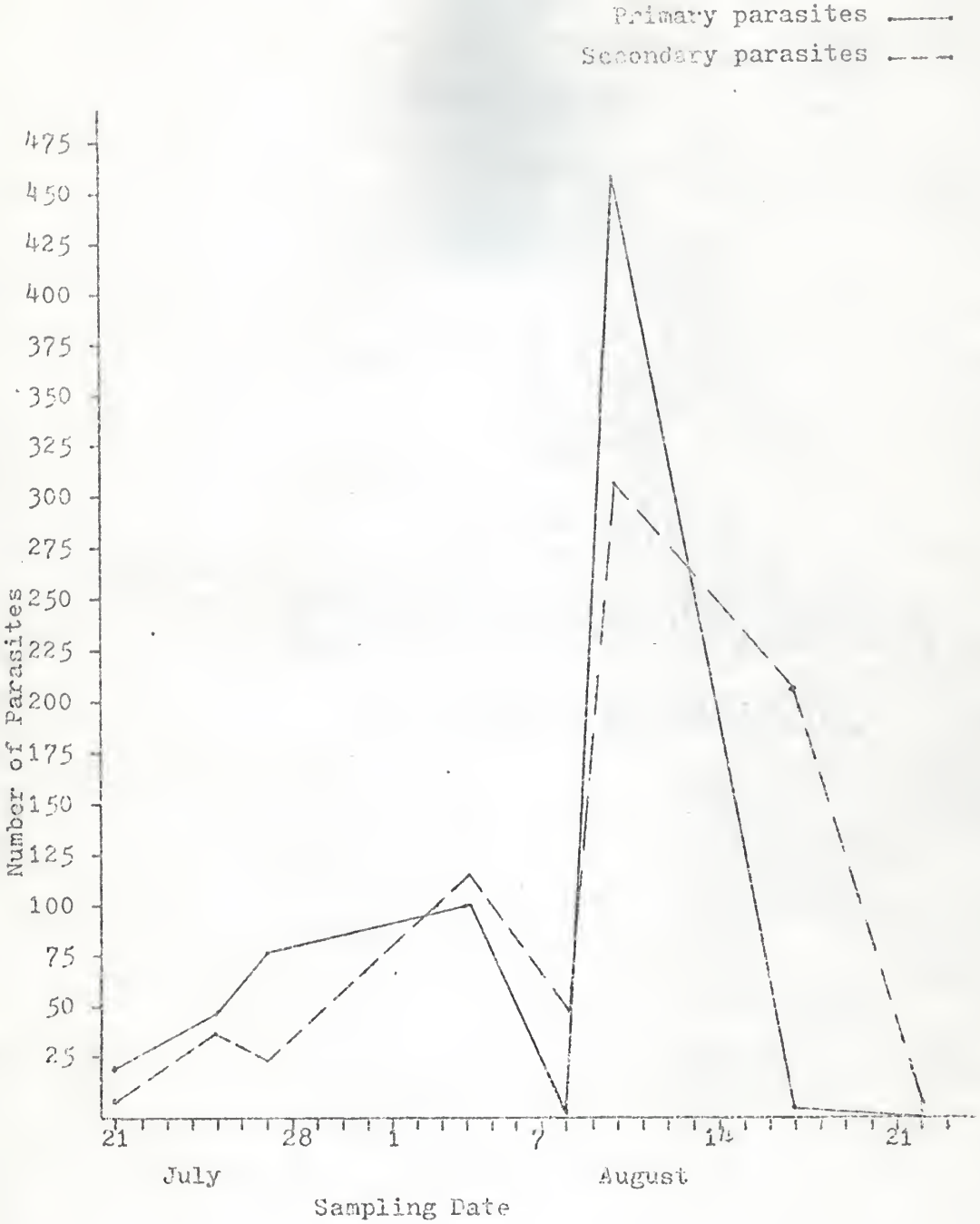

Primary parasites
Secondary parasites
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
Number of Parasites
21
28
1
7
14
21
July
August
Sampling Date

Fig. 4. The percent of primary and secondary parasites collected from greenbugs and corn leaf aphids in the southwest region of Kansas.

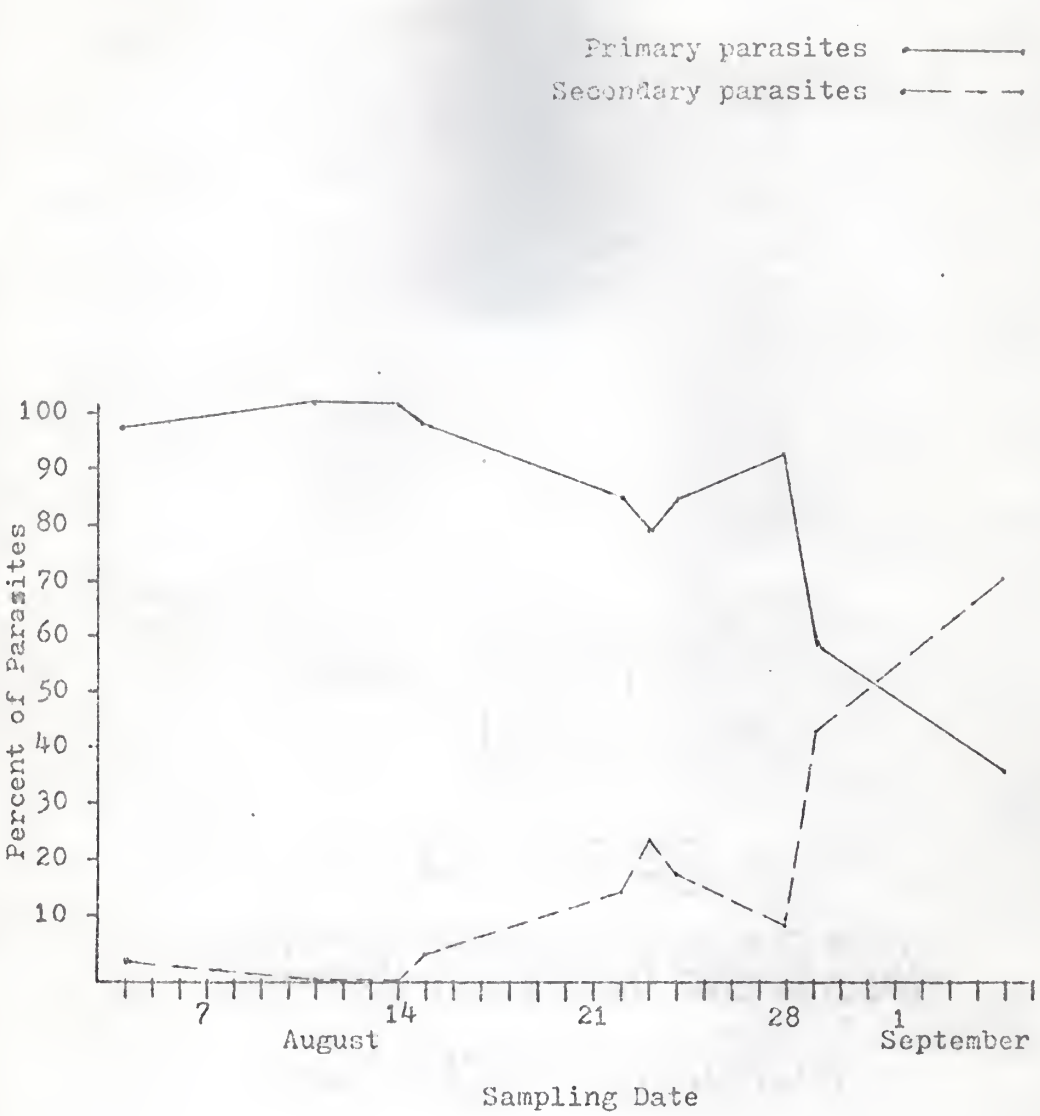
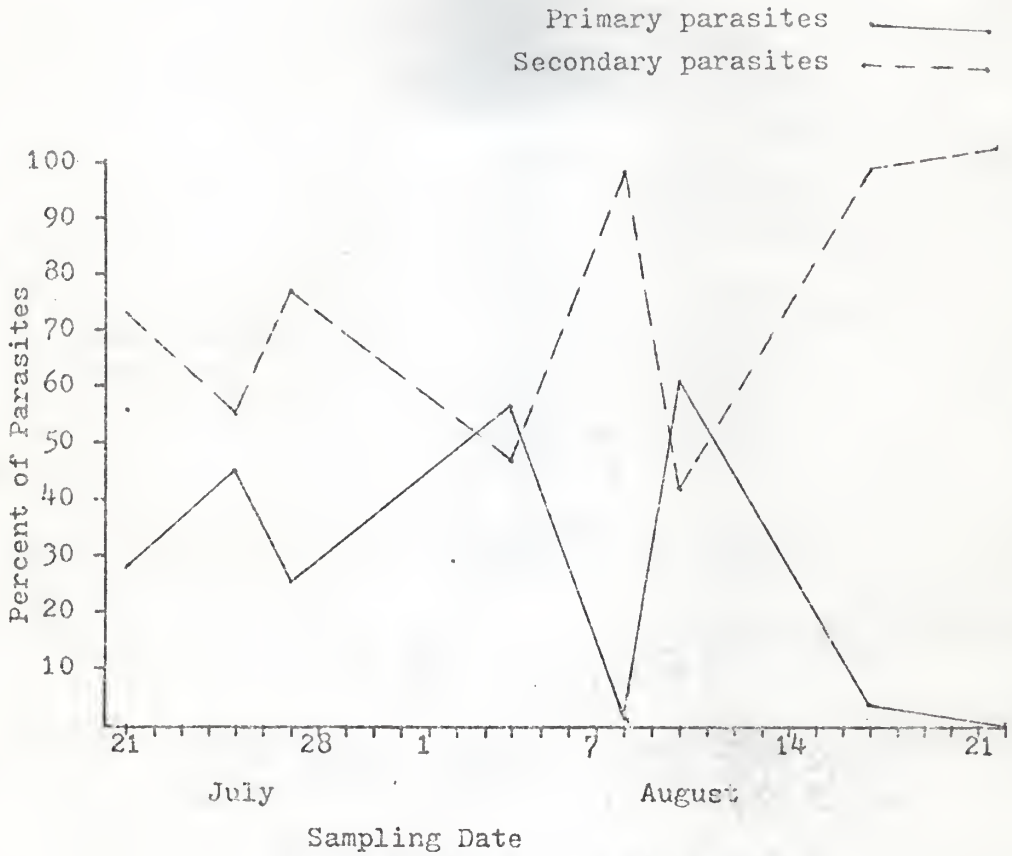

Primary parasites
Secondary parasites
100
90
80
70
60
50
40
30
20
10
Percent of Parasites
7
14
21
28
1
August
September
Sampling Date

Fig. 5. The percent of primary and secondary parasites collected from greenbugs and corn leaf aphids in the northeast region of Kansas.


Primary parasites
Secondary parasites
100
90
80
70
60
50
40
30
20
10
Percent of Parasites
21
28
1
7
14
21
July
August
Sampling Date

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The occurrence of parasites of the greenbug, Schizaphis graminum (Rondani), and the corn leaf aphid, Rhopalosiphum maidis (Fitch), on sorghum in Kansas in 1978 was studied, as well as investigations conducted into the biology and behavior of Pachyneuron siphonophorae (Ashmead), a secondary parasite of aphids.

Parasites belonging to the families Braconidae, Eulophidae, Pteromalidae, Cynipidae, and Encyrtidae were recovered from areas of north-eastern and western Kansas. Lysiphlebus testaceipes (Cresson) was the most abundant primary parasite attacking both greenbugs and corn leaf aphids. The predominant secondary parasite of both aphid species was P. siphonophorae. Other parasites recovered included the primary parasite, Aphelinus nigritus (Howard), and secondary parasites Asaphes lucens (Provancher), Aphidencyrtus aphidivorus (Mayr), and Charips sp.

The developmental period of P. siphonophorae from egg to adult was determined to range from ten to twelve days with a mean of 10.4 days.

All ages of mummified greenbugs previously parasitized by L. testaceipes were accepted as hosts by P. siphonophorae females. Adult females were observed to feed on body fluids of host pupae as the fluid exuded out the ovipositional puncture. Male P. siphonophorae exhibited a brief courtship by beating their wings and mounting the

female.

Ovipositional behavior was considered more time consuming than that of the host, L. testaceipes and is considered a determining factor in the balance between the populations of the two parasites.