Seasonal Occurrence of the Sugar Cane Woolly Aphid, *Ceratovacuna lanigera* (Homoptera: Aphididae), and Its Predators in Sugar Cane Fields of Okinawa Island

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Seasonal occurrence of the sugar cane woolly aphid *Ceratovacuna lanigera* ZEHNTNER and its predators was monitored in sugar cane fields in the southern part of Okinawa Island, Japan from October 1988 to March 1990. *C. lanigera* occurred more frequently in summer-planted fields than in ratooned fields. In summer-planted fields, new colonies of *C. lanigera* were frequently observed in November and December. These colonies gradually increased during winter. The number of infested leaves peaked in April, then decreased abruptly after insecticide spraying in April/May. *C. lanigera* was usually uncommon in summer, but in those fields where it was abundant various predators attacked the aphid colonies and quickly suppressed its increase.

Key words: seasonal occurrence, sugar cane woolly aphid, *Ceratovacuna lanigera*, predator

INTRODUCTION

The sugar cane woolly aphid, *Ceratovacuna lanigera* ZEHNTNER, is a serious pest of the sugar cane in Asia. Aphid feeding inhibits the growth of its host, and its honeydew causes the growth of a sooty mould which stains the leaves. The seasonal occurrence of *C. lanigera* in Okinawa had been briefly reported by AZUMA and OSHIRO (1971).

The abundance of aphids is greatly affected by the way the sugar cane is cultivated. In Okinawa the sugar cane is planted in spring (from February to April) and summer (from August to October). In addition there are ratooned plants that develop after the harvest of spring- and summer-planted canes. The ratooned and spring-planted canes germinate in spring, while summer-planted canes do so in autumn. The seasonal occurrence of the aphid and its predators on sugar canes is compared, mainly for summer-planted and ratooned fields.

MATERIALS AND METHODS

This study was carried out in sugar cane (NCo310) fields near the Okinawa Prefectural Agricultural Experiment Station at Naha, Okinawa from October 1988 to March 1990.

Growth pattern of sugar canes. To compare the growth pattern of summer-planted and ratooned canes, the length of 20 stalks was measured for each type at almost monthly

intervals in fields from November 1988 to October 1989 for the summer-planted canes (planted in September 1988), and from April 1989 to October 1989 for the ratooned canes. The data of temperature during the survey were provided by Okinawa Weather Forecasting Station (located about 3 km west of the study site).

Colonization by alate aphids. In order to compare the settling preference by alate aphids among three cultivation types of the sugar cane, the aphid colonies were counted in summer-planted (planted in 1988), ratooned and spring-planted canes in November 1988. Aphid colonies were counted in 10 fields each for the summer-planted and ratooned canes and in four fields for spring-planted canes. In each field, 200 stalks were checked randomly for aphid colonies.

*Seasonal occurrence of *C. lanigera* and predators.* Seasonal occurrence of *C. lanigera* and predators was recorded in five fields each of summer-planted and ratooned canes. At almost monthly intervals from October 1988 to March 1990, 200 stalks were sampled in each field and the number of infested leaves with aphids was recorded. For the infested stalks, both the aphids and predators attacking them were counted in situ if the aphid colony was small. When the colony was large, it was taken to the laboratory, and the number of aphids as well as eggs, larvae and pupae of predators was recorded. For aphids only the number of 4th instar nymphs and adults was counted, because the younger instars were too numerous to count, e.g. on a heavily infested cane, there were more than 10,000 aphids per stalk. In addition to these fields, several other infested fields were surveyed from May to November 1989. An insecticide was sprayed in the end of April in all sugar cane fields and again in the end of May in a summer-planted field in which large aphid colonies were still present.

Body weight of the predators. The weight of aphids consumed by a predator may be roughly proportional to the latter's body size. Body weight of the final instar larvae of five predators observed in the aphid colonies was measured in September and October 1989. The measurement was also made for three adult predators among them. Twenty individuals were measured for each class.

Fig. 1. Changes in the stalk length of summer-planted (A) and ratooned (B) canes (sample size: 20 stalks). Vertical bars and solid lines represent SD and air temperature, respectively.

Table 1. The number of aphid colonies per 200 stalks in summer-planted, ratooned and spring-planted sugar canes

Study plots	Summer-planted	Ratooned	Spring-planted
1	9	0	0
2	6	0	0
3	5	0	—
4	2	0	—
5	8	1	—
6	13	1	1
7	0	0	0
8	16	3	—
9	18	1	—
10	1	0	—
Mean $\pm$ SD ^a	7.8 $\pm$ 6.3	0.6 $\pm$ 1.0	0.2 $\pm$ 0.5

^a No. of aphid colonies per 200 stalks.

Fig. 2. Seasonal fluctuations in the number of leaves infested with aphids per 200 stalks in ratooned (top) and summer-planted (bottom) fields. Solid circles refer to the mean values for five fields surveyed at monthly intervals and the vertical bars indicate SD. Open circles are the values for other fields. Arrows indicate time of insecticide spraying.

RESULTS

Growth pattern of sugar canes

Canes planted in late September grew slowly until March, and rapidly from April to August (Fig. 1). The stalk length attained a mean of 259.8 ± 19.1 cm (mean $\pm$ SD) in October. The ratooned canes that germinated after the harvest in early March of

Table 2. Changes in the number of aphids and their

Date	Fields ^a	Aphid	<i>P. kurohime</i>				<i>D. aphidivora</i>		
			E ^b	L	P	A	E	L	P
1988									
Nov.	R	63	0	0	0	0	0	0	0
Dec.	R	211	0	0.4	0	0	0	0	0
1989									
Jan.	R	440	0	1.2	0	0.4	0	0	0
Feb.	R	2360	3.0	3.4	0.8	0.4	0	0	0
Mar.	R	9300	9.2	8.2	1.8	1.2	0	0	0
Apr.	R	30140	39.8	19.6	29.6	2.0	0	0	0
May	R	0	—	—	—	—	—	—	—
	Ex	34290	129	72	13	8	4	46	9
June	R	0	—	—	—	—	—	—	—
	Ex	15480	711	964	551	92	68	382	96
July	R	0	—	—	—	—	—	—	—
	Ex	0	—	—	—	—	—	—	—
Aug.	R	0	—	—	—	—	—	—	—
	Ex	12140	564	337	203	32	151	53	27
Sep.	R	0	—	—	—	—	—	—	—
	Ex	21980	253	100	21	11	15	26	5
Oct.	R	0	—	—	—	—	—	—	—
	Ex	29270	434	303	77	36	65	129	9
Nov.	R	7	0	0	0	0	0	0	0
Dec.	R	23	0	0	0	0	0	0	0
1990									
Jan.	R	68	0	0	0	0	0	0	0
Feb.	R	141	0	0	0	0	0	0	0

^a R: five census fields where the survey was regularly carried out at monthly intervals.

^b E: egg, L: larva, P: pupa, A: adult.

1989 grew rapidly from April to August, with a mean stalk length of 250 ± 22.8 cm in October.

Colonization by alate aphids

Summer-planted canes supported more aphids (7.8 ± 6.3 per 200 stalks) than the ratooned (0.6 ± 1.0) and spring planted canes (0.2 ± 0.5), as shown in Table 1.

Seasonal occurrence of C. lanigera and predators

Aphids infested the sugar cane throughout the year without aestival or winter diapause, although there were large seasonal population fluctuations (Fig. 2). *C. lanigera* was more abundant in the summer-planted than in the ratooned fields. New colonies of *C. lanigera* were frequently found in the summer-planted fields in October through December. These colonies grew slowly during winter. The number of infested leaves peaked in April, then rapidly declined after the spraying and became undetectable until autumn. In contrast, in the ratooned fields and the additional other summer-planted fields some aphids were present even after spraying. These aphids initiated colonies

predators per five stalks in summer-planted fields.

<i>E. navigatorum</i>				<i>M. kuroiwae</i>			<i>S. grandis</i>		
E	L	P	A	E	L	P	E	L	P
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	4.4	0	0	0.2	2.0	0	0	0	0
0.6	9.0	0	0	0	0.4	0	0	0	0
0	2.4	4.6	0	0.6	2.4	0	0	0	0
—	—	—	—	—	—	—	—	—	—
0	14	0	0	0	16	0	0	0	0
—	—	—	—	—	—	—	—	—	—
0	0	0	0	16	29	0	0	0	0
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
1	0	0	0	6	3	0	0	0	0
—	—	—	—	—	—	—	—	—	—
5	2	0	0	0	0	0	0	0	0
—	—	—	—	—	—	—	—	—	—
0	6	0	0	0	0	0	0	4	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Ex: additional extra census fields.

and grew gradually during winter. As cane was harvested from mid-January to late March 1990, these colonies were destroyed.

Predators were also not abundant during winter, and increased in spring through early summer, maintaining a high population until early autumn (Table 2). *Pseudoscymnus kurohime* (MIYATAKE) (Coccinellidae) was the most abundant predatory insect found in *C. lanigera* colonies throughout the year, followed by *Dipha aphidivora* (MEYRICK) (Pyralidae). This species was first observed in May, and increased between June and August in the fields. However, it was not observed in winter. *Eumicromus navigatorum* (BRAUER) (Hemerobiidae) and *Metasyrphus kuroiwae* (MATSUMURA) (Syrphidae) were generally common but not abundant, and only a few individuals were found in winter. Only four larvae and one pupa of *Synonycha grandis* (THUNBERG) (Coccinellidae) were observed at a single site in October 1989.

Body weight of the predators

Results of the measurements are shown in Table 3. For final instars, a coccinellid *S. grandis* was the heaviest, followed by the syrphid *M. kuroiwae*. The third heaviest was

Table 3. Body weight of the major predators of *C. lanigera* (Mean $\pm$ SD)

Predators	N	Final instar larva (mg)	Adult (mg)
<i>Synonycha grandis</i>	20	112.68 $\pm$ 15.31	95.16 $\pm$ 21.62
<i>Metasyrphus kuroiwa</i>	20	88.93 $\pm$ 25.17	—
<i>Dipha aphidivora</i>	20	19.36 $\pm$ 4.27	—
<i>Eumicromus navigatorum</i>	20	5.22 $\pm$ 0.58	2.78 $\pm$ 0.45
<i>Pseudoscyrnus kurohime</i>	20	1.90 $\pm$ 0.24	1.38 $\pm$ 0.16

the pyralid larva, *D. aphidivora*, and the lightest was another coccinellid *P. kurohime*.

DISCUSSION

Seasonal occurrence of *C. lanigera* in Okinawa was briefly described by AZUMA and OSHIRO (1971). They reported two peaks in abundance for most aphid species in temperate regions: a large peak in spring and a smaller one in autumn. They did not find any *C. lanigera* in the summer and winter. However, I observed that the aphid colonizing sugar canes in autumn showed a slow increase in abundance during winter and rapidly increased to outbreak levels in April, and that the outbreak levels were maintained until May if insecticides were not applied. A few colonies of *C. lanigera* were also observed in sugar cane fields during summer. I did not find any peak of occurrence in autumn (AZUMA and OSHIRO (1971) reported a small autumn peak).

C. lanigera was abundant in summer-planted fields but uncommon in ratooned fields (Table 1). Differences in the number of aphids colonizing summer-planted and ratooned fields in autumn caused a large difference in the following spring. The reason why alate aphids preferred to colonize summer-planted rather than ratooned canes was not determined. In addition to this difference, aphid colonies in ratooned cane fields were destroyed by harvesting before becoming numerous.

Predators of *C. lanigera* seem to be active throughout the year except in winter, and were most abundant in summer. The decrease in the number of fields infested by the aphid in summer may be due to the intense pressure from natural enemies as well adverse climatic conditions.

ARAKAKI and YOSHIYASU (1988) reported that eggs, larvae and pupae of the pyralid *D. aphidivora* occurred throughout most of the year in colonies of two species of aphids: *C. lanigera* on the sugar cane and *Pseudoregma bambucicola* (TAKAHASHI) on the bamboo, *Bambusa glaucescens* SIEB. ex MUNRO in the Okinawa and Sakishima Islands. In this study, *D. aphidivora* larva was observed feeding on *C. lanigera* from May to October 1989. This species may play an important role in suppressing the growth of *C. lanigera* colonies, because it is not only abundant but also relatively large in body size.

The larva of the syrphid *M. kuroiwa* was the second heaviest predator, but less abundant, and its role in suppressing aphid populations may be negligible. This species was also found only in the larger *C. lanigera* colonies.

Because of its large size and high fecundity, the coccinellid *S. grandis* has been considered to be an important natural enemy of *C. lanigera* (TAKANO, 1934; AZUMA and OSHIRO 1971). However, this species was rarely seen in this study. In October 1990, I observed *S. grandis* consuming *P. bambucicola* in Nakagusuku Village and Nago City;

it may specialize in attacking Cerataphidini tribe aphids. Another coccinellid *P. kurohime* may be an important natural enemy because it was the most abundant predator though it was smallest in body size.

Some predators listed above seem to be effective in reducing the aphid populations. Their occurrence is too late to suppress the heavy infestations by the aphid from an economic point of view, as the sugar cane is seriously damaged before the predators increase in number in the fields. *C. lanigera* was usually uncommon in summer, but in those fields where it was abundant (as in the extra fields shown in Table 2), various predators attacked the aphid colonies and quickly suppressed them. As *C. lanigera* was not abundant in autumn, the number of predators was also small.

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REFERENCES

- ARAKAKI, N. and Y. YOSHIYASU (1988) Notes on biology, taxonomy and distribution of the aphidophagous pyralid, *Dipha aphidivora* (MEYRICK) comb. nov. (Lepidoptera: Pyralidae). *Appl. Entomol. Zool.* **23**: 234-244.
- AZUMA, S. and Y. OSHIRO (1971) Studies on the insect pests of sugar cane woolly aphid, *Ceratovacuna lanigera* ZEHNTNER. *Bull. Okinawa Agric. Exp. Stn.* **5**: 9-27 (in Japanese).
- TAKANO, S. (1934) On the morphology and biology of *Ceratovacuna lanigera* ZEHNTNER, and the relation of its outbreak to environmental conditions in Formosa. *J. Formosan Sug. Pl. Ass.* **11**: 481-528 (in Japanese).