Overwintering of the Spirea Aphid, *Aphis citricola* VAN DER GOOT (Homoptera: Aphididae) on Citrus and Spirea Plants¹

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Some differences in overwintering habits were noted between the populations of *Aphis citricola* on *Spiraea thunbergii* and on *Citrus unshiu*. *A. citricola* laid eggs at almost the same time on both plants. The aphid overwintered holocyclically and unholocyclically on spirea but only holocyclically on citrus. The time of egg hatching was different on the two plants, those on spirea hatching more than a month earlier than those on citrus. The sprouting of the host plant did not lead directly to the egg eclosion. The possibility was suggested that the two overwintering populations might differ from one another in their life cycles and that a biotypic differentiation might occur in this aphid. The appearance of emigrants on spirea was more than twenty days earlier than on citrus when the citrus grove invasion began. It was suggested that the spirea emigrants might not play a major role in the spring infestation in citrus groves but that the citrus overwintering population might be important in this infestation.

INTRODUCTION

In Japan the spirea aphid, *Aphis citricola* VAN DER GOOT attacks fruit trees, such as citrus, peach, apple and pear, and also vegetables belonging to Umbelliferae. It has been reported that the species overwinters on spirea in the egg stage and then migrates to a wide range of secondary host plants including Rosaceae, Compositae, Rutaceae and Umbelliferae (EASTOP, 1966; HIGUCHI and MIYAZAKI, 1969; MORITSU, 1954; RICHARDS, 1976; SORIN, 1975; TANAKA, 1976). Recently, it was also observed that eggs overwinter on citrus (KOMAZAKI et al., 1979). This study was conducted to clarify differences in the overwintering habits of the species attacking citrus and spirea and also to compare how the two plants affect the spring infestation in citrus groves.

MATERIALS AND METHODS

Aphids in each morph and eggs were counted in a grove of *Citrus unshiu* (0.17 ha, 156 trees) and on potted *Spiraea thunbergii* (five pots with a diameter of 12.5 cm) from 1977 to 1981. Potted *C. unshiu* was also used for a winter observation and for a host exchange experiment. Observation began in the fall and continued until emigrants appeared the next spring.

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RESULTS

The appearance of sexual forms on *S. thunbergii* (ST) and *C. unshiu* (CU) in the winter of 1979–1980 is illustrated in Figs. 1 and 2. The change of morph composition observed during the next winter (1980–1981) followed fundamentally the same trend as shown in these figures. Judging from the fact that aphids were more densely populated on ST than on CU, it is likely that the former is more suitable as a winter host than the latter. On ST, twenty-eight viviparous nymphs and adults were observed at the end of January in 1980 (Fig. 1). The aphid population continued to decrease until mid-February, when it began to increase. On CU, however, all aphids had died by early February.

The sexual morphs appeared at almost the same time on ST and CU. Oviparous nymphs and adult males began to appear on both plants late in October and early in November, respectively. The percentage of sexual morphs was highest between mid- and late November, and then gradually decreased to zero by early February. Oviparae began to oviposit in mid- or late November and oviposition lasted until late December or January (Fig. 3). There was a tendency for oviposition to last slightly longer on ST than on CU.

The total number of eggs counted each year is shown in Table 1 and dates when fifty percent of the total hatched eggs eclosed are listed in Table 2. On ST eggs began to hatch late in January, while on CU they began to hatch in early or mid-March when hatching on ST had already finished. There was a one to one and a half month interval in fifty percent hatching date between the two plants. The suspicion that

Fig. 1. Appearance of sexual morphs of *A. citricola* on *S. thunbergii*. M: male (adult+nymph), Ov: ovipara (adult+nymph), Alv: adult alate virginopara (including gynopara), Apv: adult apterous virginopara, vn: nymph of virginopara. The top figures denote the total aphid number counted during each observation.

Fig. 2. Appearance of sexual morphs of *A. citricola* on *C. unshiu*. Symbols are the same as in Fig. 1.

Fig. 3. Oviposition curves in *A. citricola* on *S. thunbergii* and *C. unshiu*. ○: *S. thunbergii* in 1979, △: in 1978, ●: *C. unshiu* in 1979, ▲: in 1978.

Table 1. Total number of eggs counted during winter

Year	<i>C. unshiu</i>			<i>S. thunbergii</i>	
	Field	Caged pot	Pot	Pot	Host exchange
1977-78	77				
1978-79	107	1670	666	283	
1979-80	585			290	
1980-81	162			149	183

Table 2. Dates of fifty percent egg hatch

Host plant	Year		
	1978	1979	1980
<i>Spirea thunbergii</i>	— ^a	Feb. 4	Feb. 18
<i>Citrus unshiu</i>	Mar. 28	Mar. 19	Mar. 27

^a Not observed.

Fig. 4. Egg hatching curves in *A. citricola* on *S. thunbergii* and *C. unshiu*. ●: potted *S. thunbergii*, ○: potted *C. unshiu* in net cage, ▲: potted *C. unshiu* without cage, and △: *C. unshiu* in the grove.

some microclimatic and/or topographic conditions might be concerned in these differences in ST and CU were removed by the following study with potted plants.

In the fall of 1978, potted CU with aphids were put in a net cage and the aphids were allowed to mate and oviposit freely. Some other potted CU and potted ST were kept uncaged in order to allow the aphids to oviposit naturally. These three kinds of pots were then placed side by side and egg hatching was observed. In Fig. 4, where the result obtained in the CU grove is also demonstrated, a difference in trend among the three CU curves shows but it is small compared with the difference between ST

and CU. When the fact that ST begins to sprout early in February and CU in mid-March was taken into consideration, the egg hatch seemed to synchronize well with the sprouting of the host plant. Then the following host exchange experiment was designed to learn whether the sprouting induces the egg hatch.

In the fall of 1980 oviparae and males were transferred with a fine brush from potted CU to potted ST in a net cage and allowed to mate and oviposit freely. The reverse treatment, transfer from ST to CU, was also made. In addition, pots of both plant types with no aphid transfers were prepared. The results are shown in Fig. 5. Eggs laid by host-changed oviparae hatched at almost the same time as those on an original host, suggesting that the time of hatching was mainly determined in accordance with the history of the sexual morphs and whether they had developed on CU or ST. It is unlikely that the sprouting of the host plant was concerned in the egg hatch.

As seen in Table 3 eggs laid on ST and CU appeared to differ from each other even in hatchability. As they hatched earlier on ST than on CU, the followed developmental processes in aphid population differed on the two plant types. The time of fifty percent egg hatch, appearance of adult fundatrices and alates, the peak of alate occurrence and some indications of emigration are shown in Fig. 6. Maturation of fundatrices and, accordingly, the appearance of alates were much earlier on ST than

Fig. 5. Egg hatching curves in host exchange experiment. ▲: eggs laid on *C. unshiu* by aphids developed on *S. thunbergii*, ●: eggs laid on *S. thunbergii* by aphids developed on the same plant, ○: eggs laid on *C. unshiu* by aphids developed on the same plant, △: eggs laid on *S. thunbergii* by aphids developed on *C. unshiu*.

Table 3. Hatchability (%) of eggs on *S. thunbergii* and *C. unshiu*

Host plant	Year		
	1977-78	1978-79	1979-80
<i>Spiraea thunbergii</i>	—	26.9	39.3
<i>Citrus unshiu</i>	26.0	31.8	58.1

Fig. 6. Developmental processes in *A. citricola* populations overwintered on *S. thunbergii* and *C. unshiu*. ●: fifty percent egg hatch, ○: appearance of adult fundatrices, △: appearance of alates, ▲: peak of alate occurrence, ▨: period of alate existence on *S. thunbergii*, □: invasion of migrants to citrus grove.

^a the date was not precisely determined because observation was stopped just before alate appearance.

on CU. The time of alate invasion from the outside to citrus groves was estimated from the date of alate appearance on citrus trees on which no overwintering population existed. The start of invasion into citrus groves was twenty to forty days after the appearance of emigrants on ST; emigrants were present on ST for more than a month, being most abundant early in May. On CU the peak of alate appearance in the overwintering population took place in mid-May. Alates originating from the present overwintering population could be discriminated from those invading from the outside by whether or not alateform larvae were present in the population.

DISCUSSION

The aphid is polymorphic (HILLE RIS LAMBERS, 1966) and physiological races or biotypes are discernible in several species (BLACKMANN, 1974; FRAZER, 1972; INAISUMI, 1981; NIELSON et al., 1970). The facts the present author has clarified in his study seem to suggest the possibility of a biotypic difference existing in *A. citricola*.

In *Myzus persicae* (SULZER) egg hatching periods on peach vary in different parts of the world probably because of climatic variation (MACKAUER and WAY, 1976). Egg hatching is not synchronized with the sprouting of *Prunus* other than peach and on these plants fundatrices die by failing to settle on buds (TAKAOKA, 1960; TAKAHASHI and SORIN, 1961). Thus no differentiation in egg hatching time has been reported in *M. persicae*. In *A. citricola*, on the contrary, the egg hatching time on ST differs from that on CU even in the same district and hatching is synchronized with plant sprouting. The host change experiment showed that the sprouting of the plant did not directly induce hatching. It is therefore suggested that the eggs on the two tree types may differentiate in hatching time.

No alate was found on CU from mid-April to early May although their dispersal from ST to surrounding areas was observed to occur during this period. At this time the bud of CU had begun to sprout and fundatrices had become adults on the tree.

Emigrants appeared on CU early in May and the invasion of alates from the outside to the citrus grove occurred in mid-May. The first peak of alate infestation in groves usually takes place between late May and early June (KOMAZAKI, unpublished). At this time none or only a small number of emigrants were present on ST. The period of alate invasion overlapped more intensely with the period of the presence of alates in the overwintering population on CU than with that in the overwintering population on ST. It is therefore suggested that the former population plays a more important role in spring infestation in citrus groves than the latter. More detailed studies on these populations will give information useful in controlling the aphid in citrus groves.

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