Feeding, Reproduction and Development of *Amblyseius sojaensis* EHARA (Acarina: Phytoseiidae) on Two Species of Spider Mites and on Tea Pollen^{1, 2}

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Feeding, reproduction and development of *Amblyseius sojaensis* EHARA on *Panonychus citri* (McGREGOR), *Tetranychus kanzawai* KISHIDA and tea pollen was investigated. When *A. sojaensis* fed on the spider mites, the egg production of this phytoseiid mite was so sparse that the next generation did not develop. But when tea pollen was provided as food, *A. sojaensis* laid many eggs so that in 10 days the population increased.

The eggs of *A. sojaensis* were laid on pollen or fibrous matter and similar appearing material on the lower surface of leaves. When the mites were reared on tea pollen for long periods, clusters of eggs and chorions were observed.

INTRODUCTION

Amblyseius sojaensis EHARA has been found on sour cherry, grapevine and other plants in Japan (EHARA, 1964, 1972; INOUE et al., 1983). The authors have looked for these phytoseiid mites in many citrus groves in the Chûgoku, Shikoku and Kyûshû districts in recent years. *A. sojaensis* has been collected on windbreaks composed of Chinese black pine or Japanese cypress around citrus groves, and its possible role as an inhibiting factor of spider mites in Japan is agricultural importance. Investigations on the ecology and life history of *A. sojaensis*, however, remain incomplete.

In this study, the feeding habits of *A. sojaensis* on two species of spider mites, *Panonychus citri* (McGREGOR) and *Tetranychus kanzawai* KISHIDA, and on tea pollen were investigated. In addition, some observations were made of the ovipositional habits of this mite.

MATERIALS AND METHODS

A. sojaensis were collected at Iwaidani, in Matsuyama city, Ehime prefecture in 1983. They were reared on seedlings of citrus, to which tea pollen was added, in a constant temperature room adjusted to about 25°C. Tea pollen was collected at the National Research Institute of Tea (Kanaya, Shizuoka Prefecture), and was passed

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Fig. 1. Arrangement of experiment. When spider mites were used as prey, A: *A. sojaensis*-released leaves, B: phytoseiid mite-free leaves. When tea pollen was used as food, A: tea pollen-added leaves, B: no pollen leaves.

through a sieve (60 mesh) before using. *P. citri* and *T. kanzawai* were reared either in a green house or laboratory.

When the spider mites were used as prey of *A. sojaensis*, citrus and kidney beans were used as the respective hosts of *P. citri* and *T. kanzawai*. Eight leaves were selected from a pot of citrus seedlings and 2 leaves were chosen from each of 4 pots of kidney beans, and these leaves were then isolated from the stem by a sticky material (Tanglefoot). Adult spider mite females were inoculated on the 8 leaves of each plant, and adult females of *A. sojaensis* were inoculated on 4 leaves of each group (Fig. 1).

When tea pollen was used as food, 8 leaves of citrus and kidney bean were chosen and isolated in the same manner as described above. Tea pollen was added to 4 leaves of each plant, and then adult females of *A. sojaensis* were inoculated on all test leaves.

After the inoculation, these pots were transferred to a constant temperature room adjusted to about 25°C. The numbers of spider mites and phytoseiid mites were counted each day until the 5th day after inoculation, and again on the 10th day. Tea pollen was replaced after 5 days.

RESULTS

Feeding habits on spider mites

Table 1 shows the densities of *P. citri* and *T. kanzawai* on citrus and kidney bean. Table 2 shows the density of *A. sojaensis*. There was significant difference in the number of *P. citri* remaining on *A. sojaensis*-released and free leaves. On *A. sojaensis*-free leaves, about half of the initial number of adult females of *P. citri* remained on the 10th day after inoculation, but on *A. sojaensis*-released leaves, all of them died during the first 5 days. After 10 days, the numbers of nymphs (including larvae) and eggs of *P. citri* on *A. sojaensis*-free leaves were 118 and 49 per leaf, respectively, and on *A. sojaensis*-released leaves were 1.5 and 2 (Table 1). On citrus on the 10th day after release there were still 4.5 *A. sojaensis* individuals per leaf. The alimentary canal or entire idiosoma of many adult females of *A. sojaensis* had become dark red in color on leaves where the density of adult females of *P. citri* was lower, as a result of their ingestion of the spider mite (Table 2).

Table 1. Changes in the numbers of spider mites for 10 days after inoculation on *A. sojaensis*-released and -free leaves at 25°C

Spider mite	Phytoseiid mite	Stage of spider mite	No. of spider mites/leaf						
			0	1	2	3	4	5	10 days
<i>P. citri</i>	Release	Adult female	10	8.5	4.8	2.3	1.0	0	0
		Nymph and larva	—	0	0	0	0	0	1.5
		Egg	—	17.0	39.8	49.8	53.8	55.5	2.0
	Free	Adult female	10	9.3	9.3	8.8	8.3	7.5	4.5
		Nymph and larva	—	0	0	0	0	0	118.0
		Egg	—	17.8	45.8	80.3	94.5	136.3	49.0
<i>T. kanzawai</i>	Release	Adult female	5	3.8	3.8	3.3	2.5	1.8	34.0
		Nymph and larva	—	0	0	0	7.3	27.8	39.3
		Egg	—	10.8	28.5	39.8	42.5	32.8	258.5
	Free	Adult female	5	4.5	4.3	4.3	4.0	3.8	60.3
		Nymph and larva	—	0	0	0	10.8	31.8	68.0
		Egg	—	11.5	29.3	50.3	50.8	61.5	372.5

Table 2. Changes in the numbers of *A. sojaensis* for 10 days after release on spider mite-inoculated leaves at 25°C

Spider mite	Stage of phytoseiid mite	No. of phytoseiid mites/leaf ^a						
		0	1	2	3	4	5	10 days
<i>P. citri</i>	Adult female	10	9.3 (1.8)	9.3 (5.3)	8.5 (6.8)	8.5 (4.0)	8.3 (2.0)	4.5 (4.0)
	Nymph	—	0	0	0	0	0	0
	Larva	—	0	0.3	1.8	0.8	0	0.3
	Egg	—	3.0	3.3	1.3	0.8	0.3	0.8
<i>T. kanzawai</i>	Adult female	5	4.3 (1.0)	3.0 (0.5)	1.3	1.0	0.8	0.3
	Nymph	—	0	0	0	0	0	0
	Larva	—	0	0.3	0.5	0.8	0.8	0
	Egg	—	0.3	0.5	0.3	0	0	0

^a Figures in parenthesis show the number of adult females whose idiosoma became dark red.

When *T. kanzawai* was provided as prey, the number of adult females of *T. kanzawai* on *A. sojaensis*-released leaves increased to about 7 times the initial number by the 10th day after inoculation, and on *A. sojaensis*-free leaves, the density increased even more: after 10 days, the number of adult females on *A. sojaensis*-free leaves was about 1.8 times that on *A. sojaensis*-released leaves. Adult females of *A. sojaensis* decreased rapidly, and only 1.3 females per leaf remained after 3 days. Few of these had an alimentary canal or entire idiosoma which was dark red (Table 2).

The number of *A. sojaensis* eggs laid was very few when the two species of spider mites were provided as prey. And though a few larvae of *A. sojaensis* were observed, there were no nymphs seen during the observation period (Table 2).

Table 3. Changes in the numbers of *A. sojaensis* for 10 days after release on tea pollen-added leaves and non-added leaves at 25°C

Test plant	Food	Stage of phytoseiid mite	No. of phytoseiid mites/leaf						
			0	1	2	3	4	5	10 days
Citrus	Tea pollen	Adult female	10	8.5	8.3	7.3	7.0	6.3	13.3
		Nymph and larva	—	0	0	2.5	7.8	8.3	13.0
		Egg	—	0.3	11.0	20.8	14.5	11.0	11.3
	No food	Adult female	10	7.8	5.5	1.3	0.5	0.3	0
		Nymph	—	0	0	0	0	0	0
		Larva	—	0	0	0	0.3	0	0
		Egg	—	0	0.3	0.3	0	0	0
Kidney bean	Tea pollen	Adult female	10	9.5	9.0	9.0	9.0	9.3	29.8
		Nymph and larva	—	0	1.0	3.0	8.0	9.8	13.3
		Egg	—	4.3	14.5	23.5	18.8	15.8	9.3
	No food	Adult female	10	6.0	4.0	3.0	2.8	2.0	1.3
		Nymph	—	0	0	0	0	0	0
		Larva	—	0	0.3	0	1.0	0.5	0.3
		Egg	—	5.5	5.5	3.3	0.5	0.5	0

Fig. 2. Eggs and clusters of eggs and chorions of *A. sojaensis*. A: eggs concentrated on tea pollen, B, C: clusters of eggs and chorions.*Feeding habits on tea pollen*

Table 3 shows the densities of *A. sojaensis* on tea pollen-added leaves and non-added leaves of citrus and kidney beans. On non-added leaves of each plant, the density of adult females of *A. sojaensis* decreased rapidly and their progeny did not develop. However, many eggs of *A. sojaensis* were laid on tea pollen-added leaves. There were 20.8 and 23.5 eggs per leaf on citrus and kidney bean, respectively, on the 3rd day after release. The progeny developed well on these tea pollen-added leaves, and the number of adult females increased to about 1.3 (citrus) or 3.0 (kidney bean) times the initial number during the 10 day period (10 females/leaf).

Ovipositional habit

Larvae, nymphs and adults of *A. sojaensis* usually inhabit on the lower surface of leaves, and the majority of the eggs were laid in indentations of leaves, on pollen or fibrous matter and similar appearing place on that same surface (Fig. 2A). When *A. sojaensis* was reared on tea pollen for long periods, clusters of eggs and chorions were observed on the leaves of citrus. Many of these clusters included unhatched eggs (Fig. 2B, C).

DISCUSSION

On *A. sojaensis*-released leaves of citrus, the density of adult females of *P. citri* decreased more rapidly than on *A. sojaensis*-free leaves, and the densities of eggs and nymphs (including larvae) were sparse on the 10th day after inoculation (Table 1). Adult females of *A. sojaensis* whose alimentary canal or entire idiosoma became dark red were frequently observed with the decrease of adult females of *P. citri* (Table 2), suggesting that *A. sojaensis* fed on *P. citri*. On the 10th day after inoculation, though the densities of adult females and nymphs (including larvae) of *T. kanzawai* on *A. sojaensis*-released leaves were about half the densities on free leaves, the number of adult females on released leaves was about 7 times the initial number (Table 1). This phenomenon suggests that the phytoseiid mite feeds on *P. citri* in preference to *T. kanzawai*.

As shown in Table 2, when either *P. citri* or *T. kanzawai* was provided as prey, *A. sojaensis* laid few eggs, and individuals of the next generation did not develop. On the other hand, when tea pollen was provided as food, *A. sojaensis* laid more eggs than when no food or spider mites were provided (Tables 2, 3), and nymphs were frequently observed. In this case, the density of adult females of *A. sojaensis* increased for 10 days of after release (Table 3). Thus it is clear that *A. sojaensis* depends upon plant-derived foods such as pollen, rather than on spider mites.

The feeding habits of phytoseiid mites are various (McMURTRY et al., 1970; SHINKAJI, 1981), ranging from sarcophagous mites such as *Phytoseiulus persimilis* ATHIAS-HENRIOT, which feeds, reproduces and develops only when mites belonging to the subfamily Tetranychinae are provided as prey (ASHIHARA et al., 1978), to one requiring alternate foods such as *Amblyseius rademacheri* DOSSE, which depends on pollens of the golden glow or the Jerusalem artichoke and others (KISHI and MORI, 1979). *Amblyseius largoensis* MUMA has the wide feeding range. KAMBUROV (1971) described that feeding on the anthers of *Carpobrotus acinaciformis* promoted a higher developmental and reproductive rate of *A. largoensis* as compared with all other supplied pollen and food substances including 4 species of phytophagous mites. SAITÔ and MORI (1975) discussed the effect of pollen on development and oviposition of three species of phytoseiid mites. They described *Amblyseius longispinosus* (EVANS) as having a greater dependency on spider mites than the two following species; *Amblyseius largoensis* (MUMA) (present state: *Amblyseius eharai* AMITAI et SWIRSKI) as equally favoring pollens and spider mites; and *Amblyseius paraki* EHARA as having a high degree of dependence upon pollens. McMURTRY and SCRIVEN (1964) indicated that developmental and reproductive rates of *Amblyseius hibisci* (CHANT) on pollens were higher than those on spider mites. Though *A. paraki* and *A. hibisci* have a high degree of dependence upon pollens, they can reproduce not only when pollens are provided as food but also when only spider mites are offered as prey. In comparison with these phytoseiid mites, *A. sojaensis* laid few eggs and progeny did not develop when spider mites alone were provided as prey. Thus *A. sojaensis* seems to have higher degree of dependence upon pollens than *A. paraki* and *A. hibisci*. The results of our experiments mean that the existence of pollens or other food is essential for *A. sojaensis* to reproduce and thereby control spider mites.

KISHI and MORI (1979) observed the ovipositional situations of 4 species of phytoseiid mites from Hokkaido prefecture. They described that the eggs of *A. longispinosus* and *A. rademacheri* were concentrated where the eggs of spider mites were laid and that

the eggs of *Typhlodromus vulgaris* EHARA were laid randomly on both sides of mulberry leaves in the same manner as the eggs of *P. citri*. As the egg production of *A. sojaensis* was very low when only spider mites were provided as prey, we observed no relationship of ovipositional behavior between spider mites and this phytoseiid mite. When *A. sojaensis* was reared on tea pollen, the eggs were laid on the pollen, fibrous matter and similar appearing material on the under surface of the leaves (Fig. 2A). When the mites were reared on tea pollen for long periods, clusters of eggs and chorions were observed (Fig. 2B, C). These clusters thus seem to be a result of eggs laid one by one in fibrous matter or chorions.

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