Notes on the parasitoid fauna of the serpentine leafminer *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in Okinawa, southern Japan

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Abstract

Parasitoid fauna of the serpentine leafminer *Liriomyza trifolii* (Burgess) was surveyed in Okinawa Is., Miyako Is. and Ishigaki Is. in southern Japan from November through December 1997. A total of 12 species of parasitoids were recorded as natural enemies of *L. trifolii*; including one Braconidae, one Eucilidae, two Pteromalidae, and eight Eulophidae (7 genera). All dominating species were members of the Eulophidae. In the field, *Neochrysocharis formosa* was the most dominant species among the three islands, and the second most dominant species was *Hemiptarsenus varicornis* in Okinawa Is., *Neochrysocharis okazakii* in Miyako Is. and *Chrysocharis pentheus* in Ishigaki Is. On the other hand, in a vinyl greenhouse, the dominant species were *H. varicornis* and *N. formosa* in Okinawa Is., and *N. formosa* and *N. okazakii* in Ishigaki Is. Sex ratios of the three main parasitoid species, *H. varicornis*, *C. pentheus* and *N. okazakii*, were nearly 0.5 for the three islands. However, the sex ratio of *N. formosa* was extremely female biased 0.996 in Okinawa Is., 0.86 in Miyako Is. and 0.97 in Ishigaki Is. These facts indicate that both sexual (arrhenotokous) and asexual (thelytokous) forms of *N. formosa* occur sympatrically, and the asexual strain predominated in populations of *N. formosa*.

Key words: Parasitoid, leafminer, *Liriomyza trifolii*, *Neochrysocharis formosa*, *Hemiptarsenus varicornis*

INTRODUCTION

The serpentine leafminer *Liriomyza trifolii* (Burgess) is known as an important pest of ornamentals and vegetables throughout the world (Minkenberg and van Lenteren, 1986; Parrella, 1987). First invasion of this species in Japan was recorded in Shizuoka Prefecture, in 1990, and its distribution spread rapidly (Saito et al., 1992). A population of this species was established in Okinawa Island in 1995, and its distribution rapidly expanded throughout the Ryukyu Islands by 1996 (Kohama, 1998). Because *L. trifolii* has developed a great resistance to pesticides (Parrella and Keil, 1984; Parrella, 1987; Saito et al., 1992), commercially available parasitoids have been used as effective biological control methods in greenhouses in Europe (Wardlow, 1985). In Japan, two species of parasitoids were registered as bio-pesticides in December 1997; one is the eulophid wasp, *Diglyphus isaea* Walker, and another the braconid wasp, *Dacnusa sibirica* Telenga. For augmentative release into greenhouses, these

two parasitoid species are imported from the Netherlands. Some application experiments of these parasitoids as biological control agents in the greenhouse were conducted in Japan (Ozawa et al., 1993; Saito et al., 1995). On the other hand, it was shown that native parasitoids play important roles in the suppression of *L. trifolii* populations rather than these imported species (Saito et al., 1995). The effectiveness of the native parasitoids as biological control agents has never been tested for *L. trifolii*. Konishi (1998) listed 28 species of parasitoids of *L. trifolii* in Japan, and made an illustrated key. Sixteen parasitoid species associated with *L. trifolii* were reported in Shizuoka Pref. (Saito et al., 1996). Because of the great geographical distance and climatical difference between Shizuoka Pref. and Okinawa Pref. (temperate vs. subtropical), it is suspected that a faunal difference in native parasitoids exists between the two districts. In this paper, we report the findings of a faunal survey of native parasitoids of *L. trifolii* in Okinawa Pref., and discuss the best candidate species among many native parasitoid

species for use as biological control agents against *L. trifolii*, when we adopt augmentative release of parasitoids in the greenhouse.

MATERIALS AND METHODS

A faunal survey of the parasitoid of *L. trifolii* was conducted in Okinawa Is., Miyako Is. and Ishigaki Is., Japan, from November through December in 1997. Leaves of the kidney bean, *Phaseolus vulgaris* L., eggplant, *Solanus melongena* L., and leaflets of the tomato, *Lycopersicon esculentum* Mill., with developing *L. trifolii* mines from each of 20 plants per cultivar were randomly sampled in the open field or a vinyl greenhouse (a total of 20 leaves or leaflets per sample). In the laboratory, each leaf or leaflet was confined in a separate transparent plastic bag (15×20 cm) with a piece of paper towel to maintain a moderate moisture level. To avoid excess evaporation of moisture from the leaf, the mouth of the plastic bag was opened for the first four days, then the bag was filled with air and closed. These leaves or leaflets containing the leafminers in plastic bags were held at room temperature for three or four weeks, then the numbers of emerged *L. trifolii* adults were recorded. Emerged parasitoids were stored in vials with 70% ethyl alcohol. Some specimens were sent to taxonomists for identification of the wasps. Percentage parasitism was calculated as (emerged number of wasps)/(emerged number of wasps+emerged number of flies)×100.

RESULTS AND DISCUSSION

Percentage parasitism ranged from 19 to 44% in the field and 20 to 46% in the greenhouse (Table 1). However, these values obviously underestimated the real parasitism, because the collected leaves contained eggs or early instar larvae of *L. trifolii* which were not suitable host for parasitism due to their small size. Thus, these eggs and early instar larvae were able to continue their development and finally emerged as adults. A total of 12 species of parasitoids were recorded in the present study as natural enemies of *L. trifolii*; one Braconidae, one Eucilidae, two Pteromalidae, and eight Eulophidae (7 genera) in Okinawa (Table 2). All of these are larval or pupal parasitoids, and no egg parasitoids emerged. The number of emerged parasitoids on the leaves of three different crops, kidney bean, tomato and eggplant, were combined, because the dominant species emerged similarly from these plants (Table 2). However, minor species, *Speigaster hamugurivora* Ishii and *Speigaster* sp., emerged only from the kidney bean. *S. hamugurivora* is a pupal parasitoid (Takada and Kamijo, 1979) and it is likely that *Speigaster* sp. is also a pupal parasitoid. Most mature larvae of *L. trifolii* fall from the leaf to the ground where they pupate (Parrella, 1987). This is so in the case of the leaves of tomatoes and eggplants, but about one third of larvae pupate on the leaves of the kidney bean (Arakaki, unpublished data). Thus, such pupae

Table 1. Percentage parasitism of the serpentine leafminer, *Liriomyza trifolii* by parasitoids in Okinawa

Island surveyed	Crop	Site sampled	No. of sites sampled	No. of emerged adults		Percentage parasitism
				<i>L. trifolii</i>	Parasitoid	
Okinawa Is.	Bean	Open field	6	604	142	19
	Tomato	Open field	3	217	140	39
	Egg-plant	Open field	2	101	80	44
	Bean	Greenhouse	4	1,281	474	28
	Tomato	Greenhouse	2	114	29	20
Miyako Is.	Bean	Open field	2	392	171	30
	Tomato	Open field	1	84	49	37
Ishigaki Is.	Bean	Open field	1	62	33	35
	Tomato	Open field	3	45	56	38
	Bean	Greenhouse	1	71	33	32
	Tomato	Greenhouse	1	52	44	46

Table 2. Species composition of parasitoids of the serpentine leafminer, *Liriomyza trifolii* in Okinawa

Family	Species	Locality of island					Crop		
		Okinawa Is.		Miyako Is.		Ishigaki Is.	Bean	Tomato	Egg-plant
		OF	GH	OF	OF	GH			
Braconidae	<i>Opius</i> spp.	2 ^a (0.6) ^b		6 (2.7)	11 (12.4)	5 (6.5)	10	14	
Eucoilidae	<i>Gronotoma micromorpha</i>	3 (0.8)		1 (0.5)	1 (1.1)		4	1	
Pteromalidae	<i>Sphegigaster</i>	1 (0.3)					1		
	<i>hamugurivora</i>								
	<i>Sphegigaster</i> sp.	5 (1.4)			1 (1.1)		6		
Eulophidae	<i>Hemiptarsenus varicornis</i>	72 (19.9)	387 (76.9)	25 (11.3)	4 (4.5)	4 (5.2)	434	47	11
	<i>Diglyphus albiscapus</i>	3 (0.8)	7 (1.4)		18 (20.2)		8	20	
	<i>Qudrastichus liriomyzae</i>	3 (0.8)		3 (1.4)			4		
	<i>Pediobius</i> sp.	1 (0.3)						1	
	<i>Chrysocharis pentheus</i>	64 (17.7)	1 (0.2)	29 (13.1)	19 (21.3)	1 (1.3)	51	47	16
	<i>Neochrisocharis okazakii</i>	43 (11.9)	27 (5.4)	38 (17.2)	3 (3.4)	10 (13.0)	107	8	6
	<i>Neochrisocharis formosa</i>	165 (45.6)	81 (16.1)	118 (53.4)	31 (34.8)	57 (74.0)	227	180	45
	<i>Asecodes delucchii</i>			1 (0.5)	1 (1.1)		2		
Total		362	503	221	89	77	854	318	80

^a Number of emerged adults of each parasitoid species.

^b Percentage of composition of each parasitoid species.

OF: crops planted in the open field. GH: crops planted in the vinyl greenhouse.

on kidney bean leaves would be good targets for pupal parasitoids. This may be one reason why the pupal parasitoids were collected only from the leaves of kidney beans.

Three eulophid species, *Neochrysocharis formosa* (Westwood), *Chrysocharis pentheus* (Walker) and *Hemiptarsenus varicornis* (Girault), predominated in the open field plants (Table 2). The composition of dominant species was similar to that described for Shizuoka Pref. (Saito et al., 1996). In open field plants, *N. formosa* was the most dominant species on all three islands, and the second most dominant species was *H. varicornis* in Okinawa Is., *N. okazakii* in Miyako Is., and *C. pentheus* in Ishigaki Is. On the other hand, dominant species in the greenhouse were *H. varicornis* and *N. formosa* in Okinawa Is. and *N. formosa* and *N. okazakii* in Ishigaki Is. In Shizuoka Pref., *H. varicornis* was the most predominant species in the greenhouse (Saito et al., 1996). Thus, this species appeared to be the most important candidate for use as a biological control agent of *L. trifolii* in the greenhouse (Saito et al., 1996, 1997). The reason why this species predominated in the greenhouse remains uncertain.

In Japan, one species of Eulophidae, *Quad-*

rastichus liriomyzae Hansson et LaSalle, and one species of Eucoilidae, *Gronotoma micromorpha* (Perkins) have been reported only in Okinawa (Konishi, 1998). *Q. liriomyzae* was described as a new species in 1996, reared from *L. trifolii* in Taiwan (Hasson and Lasalle, 1996). So far, *Q. liriomyzae* have been known only from Taiwan, but this species was also found in Okinawa Is. and Miyako Is. *Q. liriomyzae* also emerged from the leafminer, *Ophiomyia cornuta* de Meijere, on the leaves of *Scaevola taccada* Roxb. *G. micromorpha* was found in 1996 in Okinawa. In the present study, *G. micromorpha* collected from fields were all females. In the laboratory rearing, the offspring of *G. micromorpha* were also all female (Arakaki, unpublished data). Therefore, *G. micromorpha* in Okinawa should propagate by female parthenogenesis (theleotoky).

In Japan, hosts of *Asecodes delucchii* (Boucek) (= *Teleopteris delucchii*) were recorded from larva of the citrus leafminer, *Phyllocnistis citrella* Stainton (Ujiye and Adachi, 1995) and the peach leafminer, *Lyonetia clerkella* (Linnaeus) (Adachi, 1998). In the present study, the leafminer *L. trifolii* was also recorded as a host of *A. delucchii*.

Table 3. Sex ratios of four dominant parasitoid species of the serpentine leafminer, *Liriomyza trifolii*

Species	Okinawa Is.	Miyako Is.	Ishigaki Is.
	Female : Male	Female : Male	Female : Male
<i>Hemiptarsenus varicornis</i>	0.43 ^a (199 : 260) ^b	0.52 (12 : 13)	— (3 : 5)
<i>Chrysocharis pentheus</i>	0.55 (36 : 29)	0.52 (15 : 14)	0.50 (10 : 10)
<i>Neochrysocharis okazakii</i>	0.53 (37 : 33)	0.53 (20 : 18)	— (3 : 0)
<i>Neochrysocharis formosa</i>	0.996 (255 : 1)	0.86 (101 : 17)	0.97 (85 : 3)

^aSex ratio: No. of females/(No. of females + No. of males).

^bNumber of emerged adults of each sex.

Sex ratios of the three main parasitoid species; *H. varicornis*, *C. pentheus* and *N. okazakii*, were almost 0.5 on the three islands (Table 3). However, the sex ratio of *N. formosa* was strongly female biased; 0.996 in Okinawa Is. ($N=256$), 0.86 in Miyako Is. ($N=118$) and 0.97 in Ishigaki Is. ($N=88$). A laboratory strain of *N. formosa* collected in Chinen, in Okinawa in October 1997 was all female, and their offspring were also all female (Arakaki, unpublished data). These facts suggest that both sexual (arrhenotokous) and asexual (thelytokous) forms of *N. formosa* occur sympatrically, with an asexual strain predominating in the field population.

N. formosa was the most dominant species on crops planted in the field in Okinawa (Table 2) and in Shizuoka (Saito et al., 1996). These dominant species would be well adapted to artificial cultivation. Asexual parasitoids may have some advantages for biological control: for example, asexual wasps do not waste hosts on production of males. Therefore, they may be cheaper to produce and have a higher population growth rate than the sexual parasitoids (Stouthamer, 1993). This is a great advantage for wasps intended for use in biological control. Therefore, the asexual strain of *N. formosa* would be a good candidate for biological control agents against *L. trifolii* in the greenhouse.

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