Hymenopterous parasitoids of the peach leafminer, *Lyonetia clerkella* (Linnaeus) (Lepidoptera: Lyonetiidae)¹

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(Received 20 October 1997; Accepted 23 January 1998)

Abstract

A total of 19 parasitoid species belonging to the families Eulophidae (17 species), Pteromalidae (1), and Braconidae (1) were reared from larvae of the peach leafminer *Lyonetia clerkella* (Linnaeus) in Tsukuba in 1993–1995. *Chrysocharis nitetis* (Walker) was the most frequent parasitoid. Species composition of parasitoids associated with *L. clerkella* in Kagoshima Prefecture was also investigated in 1995. All 13 species reared were common to those in Tsukuba, but the relative abundance of each species was markedly different.

Key words: *Lyonetia clerkella*, peach, leafminer, parasitoid

INTRODUCTION

The leafminer, *Lyonetia clerkella*, is an important pest of Japanese peach orchards. It has 6 to 7 generations a year, which scarcely overlap. The primary host of the leafminer is peach, *Prunus persica*, but the larvae also feed on various Rosaceae and *Betula* (Kuroko, 1964; Godfray, 1985). Eggs are deposited singly into the lower side of leaves. Hatching larvae penetrate into the mesophyll and form spiral and/or serpentine mines in the upper half of leaves, forming linear mines thereafter, as they grow. Mature 3rd instars leave their mines and pupate in silken cocoons suspended by silk from the underside of leaves. When larval density is high, there is heavy defoliation of peach trees, resulting in reduction in the number of fruit set the following year (Naruse, 1978).

Since the 1970s, *L. clerkella* has been intensively studied for its biology (Fujiwara et al., 1978; Naruse, 1981; Naruse and Hirano, 1990), damage pattern (Naruse, 1978) and sex pheromone (Sugie et al., 1984; Sato et al., 1986; Sonnet et al., 1987). Despite this, little attention has been given to parasitoids associated with the leafminer. The objective of the present study was to determine the hymenopterous parasitoids of *L. clerkella* larvae in peach orchards in

Japan. Understanding the parasitoid complex may be advantageous in the development of a management system for this pest using biological control agents.

MATERIALS AND METHODS

Research was conducted from July to September in 1993, and from late April to early November in 1994 and 1995 in a field of the National Institute of Fruit Tree Science (NIFTS), Tsukuba. The field had a total area of 16 ha, and several kinds of fruit trees including Japanese pear, chestnut and peach were planted.

At 2 or 3-day intervals, peach leaves containing occupied leafmines were randomly sampled from the field. In 1993, each of the leaves was individually placed in a polyethylene bag with a zipper (5 cm × 7 cm and 0.04 mm in thickness). At higher *L. clerkella* densities, more than one leafmine occurred per leaf. Therefore, in 1994 and 1995, the part containing a single leafmine was excised from the leaf, and placed in the bag as described above. At this time, the stadium and the viability of each leafminer larva was checked under a binocular stereoscopic microscope. The bags were kept in the laboratory until parasitoid adult emergence.

Representative parasitoid specimens were

¹Contribution No. 1086 of the National Institute of Fruit Tree Science.

identified by Dr. K. Kamijo (Bibai City, Hokkaido) from 1993. According to the keys he presented (Kamijo, unpublished), the author identified most of the specimens in 1994 and 1995. Braconid parasitoids were checked only in 1995 and later identified by Dr. K. Maeto (Shikoku Research Center, Forestry and Forest Products Research Institute).

Peach leaves damaged by *L. clerkella* were also sampled at the Hokusatsu Branch of the Kagoshima-ken Fruit Tree Experiment Station in Kagoshima Prefecture from May to October in 1995. These were transported to the NIFTS in Tsukuba and reared according to the procedures described above.

RESULTS AND DISCUSSION

Adults of 19 species of hymenopterous

parasitoids were reared from *L. clerkella* larvae in Tsukuba (Table 1). The total number of emerging parasitoids varied with the year, reflecting differences in the number of samplings; the densities of leafmines were virtually the same in 1994 and 1995 (Adachi, unpublished data).

In the parasitoid composition shown in Table 1, the tribe Entedoninae was represented by much more species (11 species) than the tribe Eulophinae (4). This is in contrast to the apple leafminer *Phyllonorycter ringoniella*, the larvae of which are much larger than *L. clerkella* larvae, where more Eulophinae species (15 species) were reared than Entedoninae (10) (Ujiye, 1980). What factor led the reverse composition rates of the tribes between the two leafminers? Entedoninae is generally comprised of small-

Table 1. Hymenopterous parasitoids reared from *Lyonetia clerkella* leafminers on peach leaves in Tsukuba

Family and species	Number of parasitoid adults						
	1993	1994			1995		
	Total	Male	Female	Total	Male	Female	Total
Eulophidae							
Eulophinae							
<i>Cirrospilus</i> sp.	1	56	48	104	34	15	49
<i>Zagrammosoma isonoi</i> (Kamijo)	1	112	53	165	72	60	132
<i>Pnigalio</i> sp.	43	33	16	49	16	10	26
<i>Stenomesus japonicus</i> (Ashmead)	0	5	3	8	4	2	6
Tetrastichinae							
<i>Quadrastichus</i> sp.	3	24	17	41	46	13	59
<i>Minotetrastichus</i> sp.	5	191	160	351	137	95	232
Entedoninae							
<i>Pleurotropopsis japonica</i> (Kamijo)	0	1	0	1	1	0	1
<i>Chrysocharis nitetis</i> (Walker)	82	349	283	632	366	424	790
<i>Chrysocharis pentheus</i> (Walker)					393	162	555
<i>Chrysonotomyia lyonetae</i> (Ferriere)	40	37	30	67	30	28	58
<i>Chrysonotomyia</i> sp. A		114	59	173	145	105	250
<i>Chrysonotomyia</i> sp. B		2	0	2	1	3	4
<i>Neochrysocharis</i> sp.		28	11	39	23	10	33
<i>Desmatocharis</i> sp.	0	1	2	3	0	0	0
<i>Closterocerus trifasciatus</i> Westwood	0	4	2	6	3	2	5
<i>Teleopteris delucchi</i> Bouček	25	4	6	10	2	6	8
<i>Teleopteris erxias</i> (Walker)		19	5	24	87	30	117
Pteromalidae							
<i>Trichomalopsis</i> sp.	1	0	0	0	0	0	0
Braconidae							
<i>Pholetesor</i> sp.	—	—	—	—	4	69	73
Total	201	980	695	1,675	1,364	1,034	2,398

sized parasitoid species compared with Eulophinae (Kamijo, personal communication and refer to Table 2) and tended to attack 2nd-stadium, small larvae more frequently than Eulophinae (Table 3), which may suggest that the two tribes partition host niches to some extent through utilizing hosts of different body size. If such is the case, host size can be considered to be a critical factor in determining the structure of the *L. clerkella* parasitoid complex, at least at the tribe level. Though host size has generally not been demonstrated to be related to parasitoid community structure (e.g. Askew and Shaw, 1986), Hirose (1994) emphasized its importance in research on egg parasitoid assemblages. Whether host size is an important determinant in species richness and species composition remains to be examined in larval parasitoid communities as well.

Of the parasitoids of *L. clerkella*, *Chrysocharis nitetis* and *C. pentheus* predominated, accounting for ca. 50% of the reared adults. These two species are very closely related and are classified in the same species-group

(Ikeda, 1997). This often causes great difficulty in distinguishing them from each other. Askew and Coshan (1973) examined morphological characters and found that the ratio of the distance between the anterior edge of the scutellum and the pits of the scutellar setae to that between the pits and the posterior apex of the metanotum averaged 1.06 and 1.24 in *C. pentheus* and *C. nitetis*, respectively. Although there appeared to be an overlap in the ratio ranges between the two species (Adachi, unpublished data), the measurement was usable for identification together with other criteria such as the shape of the petiole and the sculpturation of the scutellum. Three hundred twenty-four available specimens out of 632 *Chrysocharis* parasitoids in 1994 were reexamined after the identification by Dr. Kamijo: 67 males and 84 females, and 100 males and 73 females of *C. nitetis* and *C. pentheus*, respectively. *C. pentheus* tended to emerge from small 2nd-stadium host larvae more than *C. nitetis* (Table 3).

Minotetrastichus sp. was relatively abundant,

Table 2. Body length of parasitoid adults

Family and species	Mean body length (mm)±S.D. (number)	
	♂	♀
Eulophidae		
Eulophinae		
<i>Cirrospilus</i> sp.	0.98±0.23 (34)	1.51±0.33 (15)
<i>Zagrammosoma isonoi</i>	0.96±0.64 (72)	1.10±0.29 (60)
<i>PNigalio</i> sp.	1.89±0.25 (16)	2.22±0.49 (10)
<i>Stenomiesius japonicus</i>	1.38±0.29 (4)	1.60±0.28 (2)
Tetrastichinae		
<i>Quadrastichus</i> sp.	0.75±0.15 (46)	1.10±0.19 (13)
<i>Minotetrastichus</i> sp.	1.04±0.19 (137)	1.19±0.16 (95)
Entedoninae		
<i>Pleurotropopsis japonica</i>	1.40 (1)	(0)
<i>Chrysocharis nitetis</i>	1.34±0.21 (366)	1.87±0.81 (424)
<i>Chrysocharis pentheus</i>	1.01±0.21 (393)	1.45±0.26 (162)
<i>Chrysonotomyia lyonetiae</i>	0.77±0.10 (30)	1.13±0.19 (28)
<i>Chrysonotomyia</i> sp. A	0.75±0.54 (145)	0.82±0.13 (105)
<i>Chrysonotomyia</i> sp. B	1.30 (1)	1.60±0.10 (3)
<i>Neochrysocharis</i> sp.	0.81±0.10 (23)	0.97±0.13 (10)
<i>Closterocerus trifasciatus</i>	0.80±0.00 (3)	1.10±0.00 (2)
<i>Teleopteris delucchii</i>	0.55±0.07 (2)	0.92±0.34 (6)
<i>Teleopteris erxias</i>	0.76±0.11 (87)	0.95±0.16 (30)
Braconidae		
<i>Pholetesor</i> sp.	1.74±0.23 (4)	1.93±0.23 (69)

Table 3. Number of *Lyonetia clerkella* mines producing parasitoids, tabulated according to the stage of larval development at collection in 1995 in Tsukuba

Family and species		Stadium of dead larvae			Stadium of live larvae		
		1	2	3	1	2	3
Eulophidae							
Eulophinae							
<i>Cirrospilus</i> sp.	♂	0	7	27	0	0	0
	♀	0	1	14	0	0	0
<i>Zagrammosoma isonoi</i>	♂	0	54	18	0	0	0
	♀	0	16	44	0	0	0
<i>Pnigalio</i> sp.	♂	0	0	16	0	0	0
	♀	0	0	10	0	0	0
<i>Stenomesus japonicus</i>	♂	0	0	4	0	0	0
	♀	0	0	2	0	0	0
Tetrastichinae							
<i>Quadrastichus</i> sp.	♂	0	37	9	0	0	0
	♀	0	0	13	0	0	0
<i>Minotetrastichus</i> sp.	♂	0	15	122	0	0	0
	♀	0	2	93	0	0	0
Entedoninae							
<i>Pleurotropopsis japonica</i>	♂	0	0	1	0	0	0
	♀	0	0	0	0	0	0
<i>Chrysocharis nitetis</i>	♂	0	13	353	0	0	0
	♀	0	0	424	0	0	0
<i>Chrysocharis pentheus</i>	♂	0	100	293	0	0	0
	♀	1	0	161	0	0	0
<i>Chrysonotomyia lyonetiae</i>	♂	0	23	7	0	0	0
	♀	0	1	27	0	0	0
<i>Chrysonotomyia</i> sp. A	♂	1	133	10	0	1	0
	♀	0	71	34	0	0	0
<i>Chrysonotomyia</i> sp. B	♂	0	0	1	0	0	0
	♀	0	0	3	0	0	0
<i>Neochrysocharis</i> sp.	♂	0	21	2	0	0	0
	♀	0	5	5	0	0	0
<i>Closterocerus trifasciatus</i>	♂	0	1	2	0	0	0
	♀	0	0	2	0	0	0
<i>Teleopterus delucchii</i>	♂	0	2	0	0	0	0
	♀	0	5	1	0	0	0
<i>Teleopterus erxias</i>	♂	3	57	26	0	1	0
	♀	0	12	18	0	0	0
Braconidae							
<i>Pholetesor</i> sp.	♂	0	1	0	1	1	1
	♀	0	2	2	1	20	44

accounting for 14.3% of the total parasitoid adults reared in 1994 and 1995 (Table 1). Females of this parasitoid were gregarious and males were solitary: more than one female could emerge from a single host whereas only one male could emerge from a host. The numbers (frequency) of female adults emerging from a

host were 1 (55), 2 (21), 3 (11), 4 (5) and 5 (2) in 1994, and 1 (35), 2 (14), 3 (8) and 4 (2) in 1995. *Minotetrastichus* sp. was observed to be a facultative hyperparasitoid.

Trichomalopsis sp. was reared only in 1993 (Table 1). This may be the result of the sampling method of collecting only leafminer larvae

in 1994 and 1995. Bouček (1988) mentioned that the genus *Trichomalopsis* was a gregarious parasitoid in cocoons and pupae of various moths (Lepidoptera), and sometimes hyperparasitoids emerging from cocoons of hymenopterous primary parasitoids (braconids and ichneumonids). Collecting cocoons and pupae of *L. clerkella* would provide accurate information on the abundance of *Trichomalopsis* sp.

The sex ratio of the braconid parasitoid *Pholetesor* sp. was extremely biased, with females comprising 94.5% of the total number of adults (Table 1). Such biased sex ratios were not clarified in other *Pholetesor* species (e.g., Whitfield and Wagner, 1988). This braconid species may reproduce by thelytoky (Maeto, personal communication).

Pholetesor sp. eggs and/or larvae were mostly collected from living larvae of the leafminer (Table 3), but the parasitoid larvae did not complete development until the leafminer larvae had left the leaves and pupated. Thus, the mode of parasitism of *Pholetesor* sp. was koinobiosis. In contrast, all parasitoids other than *Pholetesor* sp. were idiobiosis. Askew and Shaw (1986) mentioned that, in a wide sense, idiobio-

nts tended to be generalists with broad host ranges, while koinobionts tended to be specialists with narrow host ranges. The host range of *Pholetesor* sp. should be examined in the future. The idiobiont-koinobiont dichotomy has been used to analyze the structure of parasitoid communities. In British phytophagous insects, Hawkins et al. (1990) found that, among endophytic hosts such as leafminers and gall formers, mean parasitoid assemblage size (the number of parasitoid species/host species) increased with plant size (in the series monocotyledons-herbs-shrubs-trees), and this rise was due exclusively to greater numbers of idiobiont species. Their finding that endophytic hosts on trees supported mainly idiobionts was in accord with the results of the present study.

Males of *Chrysonotomyia* sp. A, *Zagrammosoma isonoi*, *Teleopterus erxias*, *Quadrastichus* sp. and *Neochrysocharis* sp. tended to emerge more frequently from 2nd-stadium larvae than from 3rd-stadium larvae of the leafminer (Table 3), while females emerged more frequently from 3rd instars. This may imply that the sex ratios of eggs laid by adult females of these parasitoids may vary according to host size. From the viewpoint of early suppression of injury by the

Table 4. Hymenopterous parasitoids reared from *Lyonetia clerkella* leafminers on peach leaves in Kagoshima Prefecture in 1995

Family and species	Number of parasitoid adults		
	Male	Female	Total
Eulophidae			
Eulophinae			
<i>Cirrospilus</i> sp.	24	8	32
<i>Zagrammosoma isonoi</i> (Kamijo)	1	1	2
<i>Pnigalio</i> sp.	1	0	1
Tetrastichinae			
<i>Quadrastichus</i> sp.	52	14	66
<i>Minotetrastichus</i> sp.	8	10	18
Entedoninae			
<i>Chrysocharis nitetis</i> (Walker)	2	1	3
<i>Chrysocharis pentheus</i> (Walker)	170	40	210
<i>Chrysonotomyia</i> sp. A	2	0	2
<i>Chrysonotomyia</i> sp. B	1	1	2
<i>Neochrysocharis</i> sp.	9	2	11
<i>Teleopterus delucchii</i> Bouček	6	19	25
<i>Teleopterus erxias</i> (Walker)	8	2	10
Braconidae			
<i>Pholetesor</i> sp.	0	14	14

leafminer larvae, these parasitoid species attacking younger leafminer larvae can be effective as biological control agents.

Table 4 shows the species composition of hymenopterous parasitoids associated with *L. clerkella* in Kagoshima Prefecture. All 13 species reared were common to those in Tsukuba, but the relative abundance of each species was markedly different. *Chrysocharis pentheus* was most dominant, accounting for 53% of the adults reared, whereas the number of *C. nitetis*, which was the most frequent parasitoid in Tsukuba, was very low. *Quadrastichus* sp. attacking younger larvae of the leafminer was of apparent abundance in Kagoshima Prefecture.

L. clerkella is distributed widely from Asia to Europe (Inoue et al., 1982). However, information on geographical variation of the parasitoid complexes associated with *L. clerkella* is lacking. Identifying parasitoid species and investigating the relative abundance of both the leafminer and the parasitoids in various localities could provide information on effective biological agents for future management decisions.

ACKNOWLEDGEMENTS

I express my sincere thanks to Dr. Kazuaki Kamijo (Bibai City, Hokkaido) for identifying the species and reading the manuscript. I wish to thank Dr. Kaoru Maeto (Shikoku Research Center, Forestry and Forest Products Research Institute) for identification of the Braconidae. I am also indebted to Mr. Shinichi Mizushima (Hokusatsu Branch, Kagoshima-ken Fruit Tree Experiment Station) for his assistance in collecting samples of leafminers in Kagoshima Prefecture.

REFERENCES

- Askew, R. R. and P. F. Coshn (1973) A study of *Chrysocharis nephereus* (Walker) (Hymenoptera: Eulophidae) and allied species, with observations on their biology in Northern England. *J. Nat. Hist.* 7: 47-63.
- Askew, R. R. and M. R. Shaw (1986) Parasitoid communities: their size, structure and development. In *Insect Parasitoids* (J. Waage and D. Greathead eds.). Academic Press, London, pp. 225-264.
- Bouček, Z. (1988) *Australasian Chalcidoidea (Hymenoptera)*. C. A. B International, Oxon. 832 pp.
- Fujiwara, A., K. Matsumoto, Y. Tamura, K. Umeda and N. Matsuo (1978) Seasonal fluctuations in abundance of the peach leaf miner, *Lyonetia clerkella* L., in Hiroshima Prefecture. *Bull. Hiroshima Fruit Tree Exp. Sta.* 4: 23-27.
- Godfray, H. C. J. (1985) The absolute abundance of leaf miners on plants of different successional stages. *Oikos* 45: 17-25.
- Hawkins, B. A., R. R. Askew and M. R. Shaw (1990) Influences of host feeding-niche and foodplant type on generalist and specialist parasitoids. *Ecol. Entomol.* 15: 275-280.
- Hirose, Y. (1994) Determinants of species richness and composition in egg parasitoid assemblages of Lepidoptera. In *Parasitoid Community Ecology* (B. A. Hawkins and W. Sheehan eds.). Oxford University Press, Oxford, pp. 19-29.
- Ikeda, E. (1997) Revision of the Japanese species of *Chrysocharis* (Hymenoptera, Eulophidae), IV. *Jpn. J. Ent.* 65: 390-403.
- Inoue, H., S. Sugi, H. Kuroko, S. Moriuti and A. Kawabe (1982) *Moths of Japan*. Vol. 1. Kodansha, Tokyo. 966 pp.
- Kuroko, H. (1964) Revisional studies on the family Lyonetiidae of Japan (Lepidoptera). *Esakia* 4: 1-61.
- Naruse, H. (1978) Defoliation of peach tree caused by the injury of the peach leaf-miner, *Lyonetia clerkella* L. I. Influence of larval density. *Jpn. J. Appl. Entomol. Zool.* 22: 1-6 (in Japanese with English summary).
- Naruse, H. (1981) Ecological studies on the peach leafminer, *Lyonetia clerkella* L. II. Seasonal polymorphism of adults controlled by photoperiod. *Jpn. J. Appl. Entomol. Zool.* 25: 162-169 (in Japanese with English summary).
- Naruse, H. and M. Hirano (1990) Ecological studies on the peach leaf-miner *Lyonetia clerkella* L. in the peach field. *Bull. Toyama Agric. Res. Ctr.* 6: 1-81 (in Japanese with English summary).
- Sato, R., N. Abe, H. Sugie, M. Kato, K. Mori and Y. Tamaki (1986) Biological activity of the chiral sex pheromone of the peach leafminer moth, *Lyonetia clerkella* Linne. *Appl. Entomol. Zool.* 21: 478-480.
- Sonnet, P. E., A. T. Proveaux, E. Adamek, H. Sugie, R. Sato and Y. Tamaki (1987) Stereoisomers and analogs of 14-methyl-1-octadecene, sex pheromone of peach leafminer moth, *Lyonetia clerkella* L. *J. Chem. Ecol.* 13: 547-555.
- Sugie, H., Y. Tamaki, R. Sato and M. Kumakura (1984) Sex pheromone of the peach leafminer moth, *Lyonetia clerkella* Linne: Isolation and identification. *Appl. Entomol. Zool.* 19: 323-330.
- Ujiye, T. (1980) Studies on parasite complexes of the overwintering generation of the apple leaf miner, *Phyllonorycter ringoniella* (Matsumura) (Lepidoptera: Gracillariidae) in Japan. *Bull. Fruit Tree Res. Stn. C* 7: 117-151.
- Whitfield, J. B. and D. L. Wagner (1988) Patterns in host ranges within the nearctic species of the parasitoid genus *Pholetesor* Mason (Hymenoptera: Braconidae). *Environ. Entomol.* 17: 608-615.