J. Ecol. Field Biol. 29 (1): 55~60, 2006

Species Composition and Seasonal Distribution of the Endoparasitoids on *Acronicta rumicis* (Lepidoptera, Noctuidae)

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ABSTRACT: Forty six individuals out of 200 *Acronicta rumicis* larva were parasitized (23 %) in 2000, 14 individuals out of 60 (23.33 %) in 2001, and 14 individuals out of 62 (22.58 %) in 2002. The mean parasitism rate was 22.97 ± 0.38 %. The parasitism rate was 36.36 % in May and 52.78 % in October, 2000, 75 % and 50 % in May and October 2001, 71.4 % and 47.37 % in May and October 2002 and it was much higher than other months. Parasitism was occurred from May to October 2000, but it was not in June and August 2001 and June 2002. There was no difference in the monthly mean parasitism rate, but the rate was the highest in May and October. The parasitoid of the larva of *A. rumicis* was the highest by 77.02 % of parasitic wasps, and 13.51 % of parasitic flies. It was found that multiparasitism was 4.05 % and hyperparasitism was 5.41 %. In case of parasitic wasps whose parasitism rate is the highest, the rate of Braconidae and Ichneumonidae was 70.18 % and 29.82 % respectively. That is, the former has much higher parasitism rate. The parasitism rate of the larva of *A. rumicis* was found that *Microplitis* sp. is 5.28 ± 0.63 %, *Glyptapanteles liparidis* 8.62 ± 3.70 %, and *Diadegma* sp. 4.02 ± 1.28 % respectively.

Key words: *Acronicta rumicis, Diadegma* sp., *Glyptapanteles liparidis, Microplitis* sp., Parasitism

INTRODUCTION

Herbivorous insects are killed by taxonomically and ecologically diverse natural enemies such as vertebrate and invertebrate predators, insect parasitoids, nematodes, fungi, protists, bacteria, and virus. Among the natural enemies, parasitoids contribute to their high mortality during all stages of herbivorous insects unlike predators or pathogens (Hawkins et al. 1997). Parasitoids lay their eggs on the bodies of the host. The larvae of the parasitoids grow up consuming the host, and finally kill the host (Price 1984, Hochberg and Hawkins 1992, Godfray 1994, Godfray and Hassell 1997, Quicke 1997, Godfray and Shimada 1999). Parasitoids have plenty of numbers of individuals and species in ecosystem, and they play a very important role to control a host's density (Hassell 1978, LaSalle and Gauld 1991). Therefore parasitoids can be understood as a keystone species that can increase or decrease the diversity of the whole ecosystem as well as insects because numerous species can be affected if the parasitoids were eliminated in the ecosystem (Hochberg and Ives 2000). Also, parasitoids have been used on biological control of the economically important insect pests (Debach 1974, Mills and Getz 1996, Murdoch and Briggs 1996). The research of the parasitoid is still accomplishing continuously as the methods of biological control by applied entomologists until now. However we can't miss that there is lack of effort to understand various life phenomena apart from the insect that has economical value because biological control has the economical concept essentially on the base.

Acronicta rumicis is an insect which belongs to Lepidoptera, Noctuidae, Acronictinae and it ranges all areas from the Korean peninsula to Eurasia (Kim et al. 1982, Lee and Chung 1997, Shin 2001). It is generated twice a year and the appearance season of the adult insect is from April to May, from July to August (Kim et al. 1982), from April to October (Shin 2001), from May to Jun and from July to August (Lee and Chung 1997). It is known that it appears 2 times or 3 times a year in Japan (Esaki et al. 1958, Inoue et al. 1959). The larva of *A. rumicis* appears 3 times from May to November in Japan (Mutuura et al. 1975), and it appears in June and from August to September in Korea wintering as the state of a pupa (Lee and Chung 1997). The larva is known as a polyphagous insect pest assaulting the leaves of *Malus pumila* var. *dulcissima*, *Paeonia suffruticosa*, *Prunus* spp., *Prunus mume*, *Prunus persica*, *Prunus salicina*, *Populus* spp., *Pyrus* spp., *Rhododendron* spp., *Rosa* spp., *Rosa rugosa*, *Salix* spp., *Vitis vinifera* (Kim et al. 1982, Lee and Chung 1997) and *Persicaria* spp. (Mutuura et al. 1975) and *Rumex* spp. of Polygonaceae (Cho 2000). The outbreak in large numbers, however, never occurs in nature. Despite the larva eats a lot (Lee and Chung 1997).

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This paper describes a study on *A. rumicis*' parasitoid. It belongs to an aboriginal insect among the *Rumex obtusifolius* which settled down recently in naturalized plants. *R. obtusifolius* is a perennial herb and it is recorded about 10 species in *Rumex* genera in Korea. It was originated from Europe, and it came first in north area via China and it is now ranging from central to southern area in Korea (Park 1995). Its rootstock is so developed that they are founded easily it in wastelands, cultivated areas and every plain not managed. It is a common a species in the meadow and known as the plant that most herbivores which can destroy the meadow permanently (Cavers and Harper 1964). It revealed that there are 33 families and 85 species in total which take *R. obtusifolius* as their habitat and food source (Shim 2000, Shim et al. 2001). *A. rumicis* is a minor pest-insect on *R. obtusifolius* in Korea. This is the first study to examine closely mutual relationship of Plant-Insect-Parasitoids and species composition and seasonal distribution of the endoparasitoids of *A. rumicis* were closely studied.

MATERIALS AND METHODS

Investigation Sites

The size of Daejeon metropolitan city is 539.71km^2, and it is located at 127°14'~127°33' E, 36°10'~36°29' N, divided by 5 districts. The yearly average temperature is 12.3℃ and the weather is the continental climate, summer is hot and winter is cold and the temperature in January is −1.9℃ and 25.5℃ in August. The yearly average humidity is 71.3 %, the lowest is 61.6% in April, the highest is 80.1 % in July, and the difference is about 20%. The yearly average rainfall is 1,354 mm; it is focused about 50% in summer, 5~10 % in winter.

The research was performed in Yongun-dong, Panam-dong, Secheon-dong and Chu-dong, Dong-gu, Daejeon metropolitan city. Yongun-dong, Secheon-dong and Chu-dong are surrounded by Mt. Gyejok (423 m), and Secheon-dong is surrounded by Mt. Sikjang (580.67 m) and the ecosystem of the study area is comparatively good because the number of the industrial facilities is lower than other regions.

Sampling *A. rumicis*

The research was carried out for 3 years from May to October in 2000~2002 in which the larva of *A. rumicis* appears. The larva of *A. rumicis* was collected from *R. obtusifolius* that is a host plant at the area of fallow fields, creeks and valleys except road areas, cultivated land not affected from dust or human. The larva of *A. rumicis* was moved to a laboratory put in a plastic bag after collecting.

Laboratory Rearing of Field-collected *A. rumicis* and Parasitoids

The larvae of *A. rumicis* were collected from be more specific and reared in the laboratory after sorting them one by one. A parasitoid that emerged during the rearing was identified and classified, and it was reared in a growth chamber. Leaves of *R. obtusifolius* used for breeding of the larva of *A. rumicis* were only the ones that were not damaged from other insect groups or viruses. Also, the food (leaves) was washed by flowing water after removing moisture to eliminate dust and foreign materials. A leaf of *R. obtusifolius* (size = 1,017.36 mm^2 in circular shape) was supplied at first instar stage, and a new leaf was supplied whenever it reached ecdysis until its sixth instar. The food was provided to identify its feeding activity when the parasitoid escaped, and the food supply was stopped when the larva of *A. rumicis* reached the prepupa stage.

A. rumicis' larva collected was kept in the growth chamber (Vision Scientific Co., LTD, VS-91G09MN). The condition of the chamber was as followed: day temp. 27℃, RH 75 %, Lux 12000 ± 100 and night temp. 25℃, RH 75 %, Lux 0, and the ratio of LD was 14:10. *A. rumicis* was reared in a petri-dish (diameter:-height =100 mm : 15 mm) with the filter paper (85 mm #2, Whatman) which was changed everyday. Humidity was kept regularly by providing the first stage of distilled water of 1 mL. The inside of the petri-dish was disinfected using 70 % of alcohol, wiped using distilled water, and dried. The rearing condition of the parasitoid was the same as a host insect's condition, and 10 % of the sucrose solution was provided with some cotton wetted when it started to emerge.

Statistical Analysis

All statistical analyses were performed using SPSS Program, Ver. 10.0 (SPSS Inc. 2000), and the monthly parasitism rate and the parasitism rate by species were verified using Kruskal-Wallis test which is one of the nonparametric tests, because the sample size was too small.

RESULTS AND DISCUSSION

Species Composition of Parasitoids

We found out that endoparasitoids of the larva of *A. rumicis* was consisted of 2 orders, 3 families, and 8 species. It was 2 orders, 3 families, and 7 species in 2,000, and 2 orders, 3 families and 5 species in 2001 and 2002. Among these Hymenoptera is 2 families 4 species. *G. liparidis* of Braconidae and *Diadegma* sp. of Ichneumonidae appeared continuously for 3 years. Tachinidae of Diptera is 1 order and 4 families. *Compcilura concinnata* appeared in 2000 and two times in 2001. *Euexorista* sp. and *Exorista* sp. appeared just once in 2000 and one species that has big morphological difference appeared once in 2001 (Table 1).

Kim (1970) described *Ophion luteus* as a larval-pupal parasitoid of *A. rumicis* and *Gelis chosensis* as a hyperparasitoid of *G. liparidis*. Yasumatsu and Watanabe (1964) reported the *O. luteus* as a larval-pupal parasitoid of *A. rumicis* and *Apanteles sasakii* as a larval parasitoid. As a result of collecting of 6th instar of *A. rumicis* which ate the leave of *Persicaria hydropiper* at the Yongun-dong, Dong-gu, Daejeon Metropolitan city in October 2003. *O. luteus* was found 1 individual emerged but *A. sasakii* was not found. The *G. chosensis*, which is the hyperparasitoid of *G. liparidis*, was not identified and the *M. semirufus* was certified as a new hyperparasitoid of *G. liparidis*. Among Tachinidae, 4 species including *Exorista* sp. and *C. concinnata*, *Euexorista* sp. were recorded as parasitic insect belonging to genus *Acronicta*, and a species which is morphologically very much different from other parasitic fly was reported to be a larval-pupal parasitoid of *A. rumicis*. The present

Table 1. Species composition and parasitism rate of parasitoids on *A. rumicis*

Month	Gly	Mic	Icn	Dia	Tac	Com	Eue	Exo	G+M	G+T	G+C	M+C	TP	NA	P (%)
							2000								
May	4	0	1	4	1	0	0	0	2	0	0	0	12	33	36.36
June	0	0	1	3	0	0	2	0	0	0	0	0	6	58	10.34
July	2	0	0	2	0	0	0	0	0	0	0	0	4	32	12.5
Aug.	1	1	0	1	0	0	0	0	0	0	0	0	3	20	15
Sept.	1	0	0	1	0	0	0	0	0	0	0	0	2	21	9.52
Oct.	4	8	0	0	2	1	0	1	0	1	1	1	13	36	52.78
Total	12	9	2	11	3	1	2	1	2	1	1	0	46	200	23
							2001								
May	1	1	0	0	1	0	0	0	0	0	0	0	3	4	75
June	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
July	0	0	0	1	0	0	0	0	0	0	0	0	1	8	12.5
Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Sept.	2	5	0	1	0	0	0	0	0	0	0	0	8	31	25.81
Oct.	0	1	0	0	0	1	0	0	0	0	0	0	2	4	50
Total	3	7	0	2	1	1	0	0	0	0	0	0	14	60	23.33
							2002								
May	0	1	0	0	0	0	0	0	0	0	0	0	1	14	7.14
June	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
July	1	0	0	1	0	0	0	0	0	0	0	0	2	7	28.57
Aug.	0	0	0	1	0	0	0	0	0	0	0	0	1	5	20
Sept.	1	0	0	0	0	0	0	0	2	0	0	0	1	7	14.29
Oct.	1	5	0	0	1	0	0	0	0	0	0	0	9	19	47.37
Total	3	6	0	2	1	0	0	0	2	0	0	0	14	62	22.58

Gly, *Glyptapanteles liparidis*; Mic, *Microplitis* sp.; Ich, Ichneumonidae; Dia, *Diadegma* sp.; Tac, Tachinidae; Com, *C. concinnata*; Eue, *Euexorista* sp.; Exo, *Exorista* sp.; G+M, *G. liparidis* & *M. semirufus* (Hyperparasitism); G+T, *G. liparidis* & Tachinidae (Multiparasitism); G+C, *G. liparidis* & *C. concinnata* (Multiparasitism); M+C, *Microplitis* sp. & *C. concinnata* (Multiparasitism); TP, Total parasitized larva; NA, No. of larva (*A. rumicis*); P (%), Parasitism (%).

work on the parasitoid of *A. rumicis* is the first study in Korea and we have identified that there are 2 orders, 3 families, and 8 species from this research. As a result, it is proved that there are 2 orders, 3 families, and 11 species in total including 2 orders, 2 families, and 3 species recorded in the documents.

Total Parasitism Rate

The number of *A. rumicis* larva collected for 3 years was 322 and 74 among those individuals were parasitized. The parasitism rate were 23 % (46 out of 200), 23.33% (14 out of 60), and 22.58 % (14 out of 62) in 2000, 2001 and 2002, respectively. The mean parasitism rate of all 3 study years was 22.97 ± 0.38 % (Table 1).

Although it is somewhat obscure to compare with *Lymantria dispar* which is the major pest in forest, 22.97 %, the mean parasitism rate of *A. rumicis* seems to be lower than 20 % and 40.8 % that Hoch et al. (2001) reported as the parasitism rate of the *L. dispar* in Slovakia and Austria respectively and 34.4 % that Zolubas et al. (2001) reported as the parasitism rate of *L. dispar* in Lithuania, considering the host plants of the larva of both species are polyphagous. As *L. dispar* has wider range of host plants than *A. rumicis* and the size of *L. dispar* larvae is much greater than those of *A. rumicis* (55~60 mm compared to 30 mm, respectively), one may assume that more parasitoids can use it as a host.

Monthly Parasitism Rate

The parasitism rates in May and October were much higher than in other months and they were 36.36 % and 52.72 % in 2000, 75 % and 50 % in 2001, and 7.14 % and 47.37 % respectively in 2002 (Table 1). Parasitism occurred from May through October in 2000, but there was no parasitism occurred in June and August in 2001 and in June in 2002. There was no difference in the monthly mean parasitism rate, but the rate was highest in May and October (39.50 ± 34.04 % in May and 50.05 ± 2.70 % in October) and it tended to lower in June (3.45 ± 5.97 %) (Fig. 1). There was no statistical differences found among monthly parasitism rates but it was suggest that the rate would be the highest in May and October due to the interspecific among *R. obtusifolius*, *A. rumicis*, and the parasitoids.

A. rumicis appears more than twice from April to October (Shin 2001), and the life cycle is around 40 days, and first appearance of the larva of *A. rumicis* was in May at the study area (Cho 2000). It can be understood that the peak period of the larva of *A. rumicis* is in May, July and September. The population dynamics of *A. rumicis* follows the biology of *R. obtusifolius* which is growing its leaves from April to May (Park 1995) and falling its leaves from June to August. The leaves are growing again in September. Known as a multiphagous or polyphagous parasitoid, the parasitism rate of

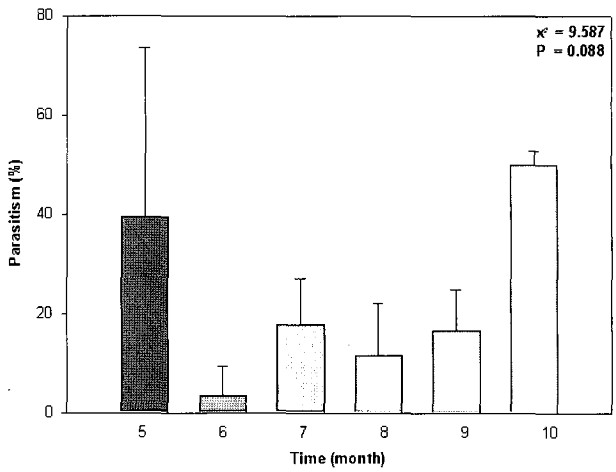

Fig. 1. Percentages mean parasitism by parasitoids on *A. rumicis*, in each sampling month from 2000 to 2002.

Microplitis sp., *G. liparidis*, *C. concinnata*, *Exorista* sp. are highest in May and October because they move to find other host insect from June to September in which the nutrition condition of *A. rumicis* is not good. In October, the parasitism rate is highest when the parasitoids lay eggs where the oviposition occurs at random regardless of its competition types being intraspecific or interspecific (Godfray 1994, Quicke 1997). Actually multiparasitism and hyperparasitism occurred 7 times in total in this research and 5 out of 7 occurred in October.

Parasitism Rate by Taxon

The highest parasitoid of *A. rumicis* was parasitic wasps by 77.02 %, and parasitic flies by 13.51 %. It was researched that multiparasitism was 4.05 % and hyperparasitism was 5.41 %. In case of parasitic wasps which showed the highest parasitism, the percent parasitism by Braconidae and Ichneumonidae ware 70.18 % and 29.82 %, respectively (Fig. 2).

Though parasitic wasps occupies 80 % of the whole parasitoids

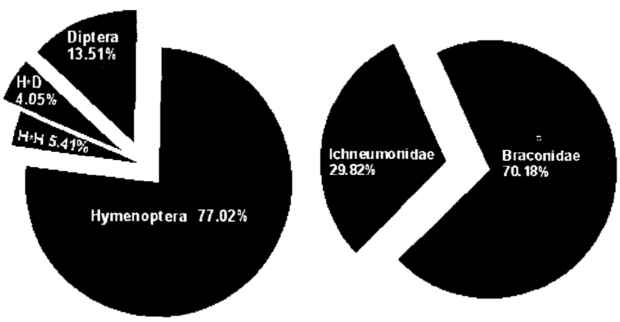

Fig. 2. Composition of parasitoids on *A. rumicis*.
H*D, Hymenoptera*Diptera (Multiparasitism); H*H, Hymenoptera*Hymenoptera (Hyperparasitism).

(Quicke 1997), it is not superior compared to parasitic flies regarding the parasitism rate among the whole insects. Kenis and Vaamonde (1998) reported that Hymenoptera was 38 % and Diptera was 42 % in case of parasitism by taxon for *L. dispar* at the North America. Lee and Lee (1996) reported that Hymenoptera was 45 % and Diptera was 55 % in case of parasitism of *Lymantria mathura*. In addition, Hoch et al. (2001) reported that Hymenoptera was 54 % and Diptera was 46 %, when the parasitism of *L. dispar* by taxon was added to larval parasitoids and pupal parasitoids in Slovakia.

Parasitism Rate by Species

The parasitism composition of the larva of *A. rumicis* was researched that *Microplitis* sp. is 5.28 ± 0.63 %, *G. liparidis* 8.62 ± 3.70 %, and *Diadegma* sp. 4.02 ± 1.28 % respectively (Fig. 3). The two species of parasitic wasps in Braconidae occupied more than 60 % of total parasitism. If we include *Diadegma* sp. in Ichneumonidae, they occupy more than 78 % of total parasitism rate (22.97 ± 0.38 %).

Although *Microplitis* sp. had never been dealt in depth because it wasn't appeared as the parasitoid of *L. dispar* and *Dendrolimus spectabilis* which are important pests, it is one of the most important endoparasitoids in the parasitism of the larva of *A. rumicis*. *G. liparidis* is a very important natural enemy of *L. dispar* and shows maximum 47.6 % (when the density of the larva or *L. dispar* is low), minimum 3 % (when the density of the larva or *L. dispar* is high) and average 15 % of parasitism rate (Schopf and Hoch 1998). It is known to be the second largest parasitoid to regulate the density of larva of *A. rumicis*. Also, *Diadegma* sp. used as a biological control agent of *Plutella xylostella* was found out the 3rd parasitoids group to control the density of the larva of *A. rumicis*. *C. concinnata* is an important parasitoid of *L. dispar* in the United States and it is appeared that about 1 % is parasitic on the *A. rumicis*.

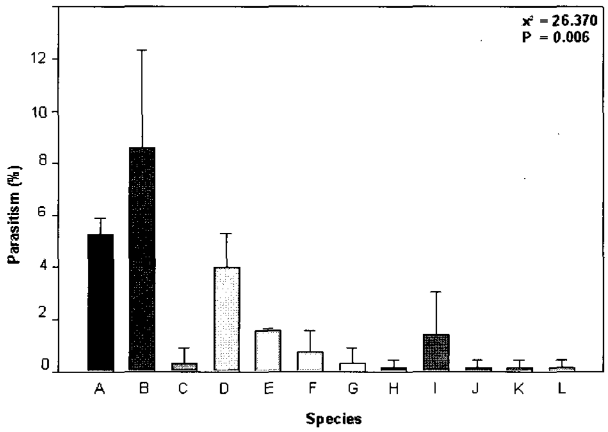

Fig. 3. Comparison of mean parasitism by parasitoids on *A. rumicis*. A, *G. liparidis*; B, *Microplitis* sp.; C, Ichneumonidae; D, *Diadegma* sp.; E, Tachinidae; F, *C. concinnata*; G, *Euexorista* sp. ; H, *Exorista* sp.; I, *G. liparidis* & *M. semirufus* (Hyperparasitism); J, *G. liparidis* & Tachinidae (Multiparasitism); K, *G. liparidis* & *C. concinnata* (Multiparasitism); *L, Microplitis* sp. & *C. concinnata* (Multiparasitism).

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(Received January 17, 2006; Accepted February 16, 2006)