スギカミキリの寄生バチの生活史および丸太接種幼虫に対する寄生状況

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論文

Life Histories of the Parasitoid Wasps and Their Percent Parasitisms on Inoculated Larvae of the Cryptomeria Bark Borer, *Semanotus japonicus* LACORDAIRE (Coleoptera: Cerambycidae)*

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URANO, Tadahisa and ITO, Kensuke: **Life histories of the parasitoid wasps and their percent parasitisms on inoculated larvae of the cryptomeria bark borer, *Semanotus japonicus* LACORDAIRE (Coleoptera: Cerambycidae). J. Jpn. For. Soc. 75: 409〜415, 1993** The parasitoid wasps on larvae of *Semanotus japonicus* LACORDAIRE, their life histories and percentages of parasitism in 10 stands of Japanese cedar, *Cryptomeria japonica* D. DON, were determined from 1990 to 1992. Four ectoparasitoid wasps, *Doryctes yogoi* WATANABE, *Ischnoceros sapporensis* UCHIDA, *Atanycolus initiator* (FABRICIUS) and *Spathius brevicaudis* RATZEBURG, emerged from *S. japonicus* larvae which were inoculated into cryptomeria logs. *D. yogoi* is a gregarious species and the others are solitary. *D. yogoi* was the predominated species and has two generations per year. The emergence period, May to June, of overwintered generations are well-synchronized with the feeding period of *S. japonicus* larvae. Adults emerge in July and August, and seem to parasitize larvae of *Palaeocallidium rufipenne* MOTSCHULSKY. The development from egg to emergence is nearly one and a half months in summer. *I. sapporensis* is the largest in size, and it emerges slightly earlier than *D. yogoi*. *A. initiator* and *S. brevicaudis* were few in numbers and seem mainly to parasitize pine beetles. On most study sites, 60〜90% of the inoculated *S. japonicus* larvae were killed by the parasitoids. *D. yogoi* and *S. sapporensis* predominated on every site, and the percent parasitism of each species changed with the year on the same site.

浦野忠久・伊藤賢介：**スギカミキリの寄生バチの生活史および丸太接種幼虫に対する寄生状況 日林誌 75：409〜415, 1993** スギカミキリ丸太接種幼虫に対し，4種の寄生バチが確認された。いずれも外部寄生で，内3種は単寄生，1種は多寄生バチであった。その中でも唯一多寄生のヨゴオナガコマユバチ（*Doryctes yogoi* WATANABE）が最も数多く採集された。本種は年2世代を経過し，7〜8月に羽化する夏世代成虫は次世代の寄主として主にヒメスギカミキリに産卵するものと考えられる。夏世代の野外での卵から羽化までの所要期間はおよそ1.5カ月であった。サッポロマルズオナガヒメバチ（*Ischnoceros sapporensis* UCHIDA）は4種の内最も大型のハチで，羽化時期はヨゴオナガコマユバチよりやや早いが，詳しい生活史は不明である。キタコマユバチ（*Atanycolus initiator* (FABRICIUS)）および*Spathius brevicaudis* RATZEBURGは主にマツの穿孔虫類を寄主としており，スギカミキリに対する寄生は少なかった。スギカミキリ接種幼虫に対する寄生率はほとんどの試験地で60〜90%に達した。いずれの場所においてもヨゴオナガコマユバチとサッポロマルズオナガヒメバチが優占していたが，それぞれの種の寄生率は同一試験地でも年によって大きく変動する傾向があった。

I. Introduction

The cryptomeria bark borer, *Semanotus japonicus* LACORDAIRE infests the phloem and wood of Japanese cedar, *Cryptomeria japonica* D. DON and Japanese cypress, *Chamaecyparis obtusa* (SIEB. and ZUCC.) ENDL. It causes serious reduction of the commercial value of the timbers. Adults emerge from host trees in spring and lay eggs in bark crevices. Hatched larvae feed on the phloem and sapwood. In late summer, full-grown larvae

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penetrate the wood and make pupal chambers in which they pupate and overwinter as adults (KOBAYASHI, 1985).

Although a number of studies have been made on the biology of *S. japonicus*, little is known about their natural enemies. NOBUCHI *et al.* (1987) and ITO and KOBAYASHI (1988) reported some instances of parasitism on the larvae of this species in weakened Japanese cedar trees, but there has been no intensive researches on their biology. In this paper, we describe four species of wasps parasitic on the larvae of *S. japonicus* in a Japanese cedar stand, their life histories and the percentage of parasitism on the larvae of *S. japonicus* which were inoculated artificially into the logs.

II. Materials and Methods

This study was conducted from 1990 to 1992. In April of each year, living Japanese cedar trees were felled and cut into 1.5 m logs at Minoo City, Osaka Prefecture, for their inoculation of hatched larvae of *S. japonicus*. The logs used for the experiment were 8.1～15.6 cm in diameter, and both ends of the logs were coated with paraffin to prevent desiccation.

In early May of each year, 40 artificial crevices were made on each log by stripping the outer bark with a cutter knife. One or two larvae of *S. japonicus*, within a few days after hatching in the laboratory, were inserted into each crevice, and the crevices were sealed with sticky tapes. These logs were hauled to the study sites in late May or early June. They were put against living trees to expose them to attacks by parasitoids. The periods and the numbers of logs set on each study site are shown in Table 1. All of the study sites were in 15～25-year-old Japanese cedar plantations.

Sample logs were carried back to the laboratory (Kansai Research Center in Kyoto City) in October 1990, and in July of 1991 and 1992. In 1992, sample logs set on Site No. 1 were brought back to the laboratory every two weeks from early June to late July to learn the developmental stages of parasitoids. After debarking, the numbers of parasitized or unparasitized larvae of *S. japonicus* were counted, and the developmental stage

Table 1. Outline of study sites

Site Nos.	Localities	Infestation levels*	Setting periods**		(Numbers of logs)
1	Kyoto	Heavy	May 24 ～ Oct. 11	1990	(4)
			May 27 ～ Jul. 10	1991	(15)
			May 22 ～ Jun. 9	1992	(4)
			May 22 ～ Jun. 19	1992	(4)
			May 22 ～ Jul. 6	1992	(4)
			May 22 ～ Jul. 20	1992	(4)
2	Ohno, Fukui	Heavy	May 23 ～ Oct. 19	1990	(4)
			May 28 ～ Jul. 17	1991	(4)
			May 28 ～ Jul. 13	1992	(4)
3	Mikata, Fukui	Heavy	May 28 ～ Jul. 18	1990	(4)
4	Kanazu, Fukui	Heavy	Jun. 4 ～ Oct. 19	1990	(4)
			May 28 ～ Jul. 17	1991	(4)
			May 28 ～ Jul. 13	1992	(4)
5	Eiheiji, Fukui	Non-infested	Jun. 4 ～ Oct. 19	1990	(4)
			May 28 ～ Jul. 17	1991	(4)
6	Kanazu, Fukui	Light	Jun. 4 ～ Oct. 19	1990	(4)
			May 28 ～ Jul. 17	1991	(4)
7	Maruoka, Fukui	Light	May 29 ～ Jul. 16	1991	(4)
8	Ohno, Fukui	Light	May 29 ～ Jul. 17	1991	(4)
9	Matsusaka, Mie	Heavy	May 29 ～ Jul. 15	1992	(4)
10	Santo, Hyogo	Heavy	Jun. 1 ～ Jul. 16	1992	(4)

* Percentage of infested trees is represented by light (1 ～ 10%) and heavy (over 31%). ** Periods of setting sample logs at study sites.

of parasitoids was determined. Eggs and feeding larvae of the parasitoids were reared with their hosts in styrene cases until emergence. Even when adults had emerged already, identification of parasitoids was possible by the shapes of the cocoons.

The numbers of emerging adults of the overwintered generation were investigated from dead cedar trees (stools with almost 1.5 m height) which were collected in Takefu, Fukui Prefecture, in November 1991 and kept in an outdoor cage at the Research Center until the following year. These trees were infested with *S. japonicus* and *Palaeocallidium rufipenne* MOTSCHULSKY.

Body lengths and ovipositor lengths of adults of the parasitoids which emerged from the sample logs in this study were measured with a micrometer. Fresh weights also were determined with a microbalance on the day of emergence.

Ⅲ. Results

1. *Parasitoid wasps*

Ectoparasitoid wasps emerging from *S. japonicus* were three species of Braconidae and one species of Ichneumonidae (Table 2), all of which were polyphagous. Only *Doryctes yogoi* WATANABE is gregarious which oviposits one to five eggs on one host larva. The other species are solitary. They parasitize several species of beetles such as *P. rufipenne*, infesting weaken or dead Japanese cedar and cypress (WATANABE, 1954). *Atanycolus initiator* (FABRICIUS) and *Spathius brevicaudis* RATZEBURG are major parasitoids on subcortical beetles infesting Japanese pine trees, red, *Pinus densiflora* SIEB. et ZUCC. and black, *P. thumbergii* PARL. (URANO and HIJII, 1991). *S. brevicaudis* was very few in this study.

The average body sizes of the three major species are given in Table 3. In this case, *D. yogoi* adults which emerged from *P. rufipenne* are included because a part of the sample logs were infested with both *S. japonicus* and *P. rufipenne*. There was much size variability in males and females of the three species. In *D. yogoi* and *Ischnoceros sapporensis* UCHIDA, females were significantly heavier than males. *I. sapporensis* was significantly larger than *D. yogoi* in every size parameter (Table 3). The ratios of the ovipositor lengths to the body lengths in *I. sapporensis* and *D. yogoi* were 0.50 and 0.75, respectively. There is a difference between the ratios, showing that the female of *D. yogoi* has a long ovipositor relative to the body length.

2. *Life histories of the parasitoids*

The numbers of parasitoids in sample logs are given in Table 4. In 1990, all of the parasitoids already had emerged because the logs were debarked in October (Table 1). The number of emerging adults of *D. yogoi* was the largest of the three species. In 1991 and 1992, debarking was done in July. The percentages of *I. sapporensis* emerging in both years were more than those of *D. yogoi*, suggesting that *I. sapporensis* emerged earlier than *D. yogoi* in the cedar stand.

Figure 1 illustrates the seasonal changes in the percentages of parasitized larvae of *S. japonicus* and each stage of *D. yogoi* in sample logs which were set on Site No. 1 in 1992. By June 9, about 20% of the host larvae were parasitized. By June 19, more than 75% were parasitized, and most of parasitoids were eggs or larvae.

Table 2. Parasitoid wasps emergimg from sample logs

Species	Solitary or gregarious	Host species other than *S. japonicus*
Braconidae		
Doryctes yogoi WATANABE	Gregarious (1～5 individuals)	*Palaeocallidium rufipenne* MOTSCHULSKY*
Atanycolus initiator (FABRICIUS)	Solitary	Cerambycidae and Curculionidae in Japanese pine trees**
Spathius brevicaudis RATZEBURG	Solitary	Cerambycidae, Curculionidae and Scolytidae in Japanese pine trees**
Ichneumonidae		
Ischnoceros sapporensis UCHIDA	Solitary	*P. rufipenne*** *Callidium violaceum* (LINNÉ)***

* WATANABE (1954). ** URANO and HIJII (1991). *** KUSHIGEMATI (1972).

By July 6, the greater part of the parasitoids had spun cocoons and reached full-grown larvae or pupae. Almost 30% of the parasitoids emerged by July 20, and other individuals also had emerged by mid-August, but several individuals entered dipause without pupation in their cocoons. In *D. yogoi*, the time from egg to emergence thus was nearly one and a half months in Kyoto City.

A female wasp of *D. yogoi* inserts her ovipositor under the bark and lay 1～5 eggs on one host larva. Each egg, about 1.2 mm in length, is white and cylindrical. The hatched larvae attach themselves to the host and suck out the host body fluids. Most parts of the host body, except for the head capsule and the integument, is consumed by the parasitoid larvae. The mature larvae spin cocoons and pupate in them.

Figure 2 shows the emergence pattern of the overwintering generation of *D. yogoi* from the sample logs which were collected in the autumn of 1991. Adults of *D. yogoi* emerged from the logs during the period from May 10 to June 12. There was a two-day difference in the date of 50%-cumulative emergence of adults between the sexes; May 26 in male and May 28 in female.

3. Percent parasitism of four parasitoids on the inoculated larvae of S. japonicus

Figure 3 shows the percentages of *S. japonicus* larvae which were parasitized by four parasitoids in the

Table 3. Sizes of the three parasitoid wasps

Species / Size parameters		Mean ± SD	Min-Max	*n*
D. yogoi				
B.W.*	♀	9.60±3.01	2.38-16.88	248
	♂	3.17±1.09	1.29-5.15	35
B.L.**	♀	6.5±0.8	4.1-8.1	132
	♂	5.1±0.5	4.1-6.0	45
O.L.***		4.9±0.5	3.0-6.6	159
I. sapporensis				
B.W.	♀	28.29±5.50	16.20-40.10	36
	♂	9.01±3.46	5.40-15.51	5
B.L.	♀	10.5±1.2	7.9-12.1	24
	♂	7.8±1.6	4.3-9.8	9
O.L.		5.3±0.2	5.0-5.6	9
A. initiator				
B.W.	♀	20.96±15.17	5.77-41.67	3
	♂	4.25±1.38	3.04-6.59	4

* Body weight (mg f. wt). ** Body length (mm).
*** Ovipositor length (mm).

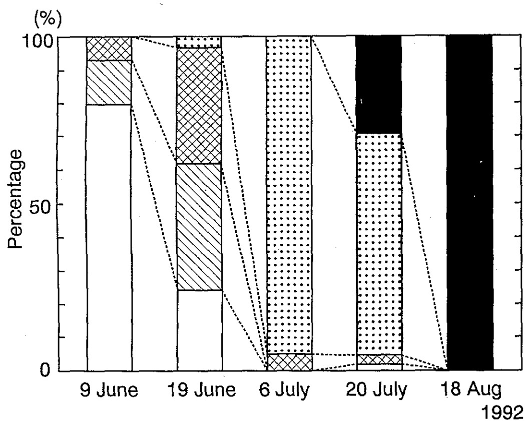

Fig. 1. Seasonal changes in the percentage of unparasitized larvae of *S. japonicus* and each stage of *D. yogoi* in sample logs set on Site No. 1

Legend: ▭, Unparasitized; ▧, Egg; ▩, Host-feeding larva; ⁙, Cocoon (full-grown larva or pupa); ■, Cocoon after emergence (CAE).

Table 4. Number of parasitoids in each developmental stage in the sample logs

Years	Species	Number of				
		Larvae*1	Cocoons	CAE*2	Adults*3	% Emergences*4
1990	*D. yogoi*	0	0	719	36.0	100.0
	I. sapporensis	0	0	184	9.2	100.0
	A. initiator	0	0	2	0.1	100.0
1991	*D. yogoi*	48	345	532	23.7	57.5
	I. sapporensis	0	28	169	5.1	85.8
	A. initiator	0	7	41	1.2	85.4
1992*5	*D. yogoi*	3	520	92	38.4	15.0
	I. sapporensis	0	18	32	3.1	64.0

*1 Stage of host-feedings. *2 Cocoons after emergences. *3 Number of emerging adults per sample log. *4 (No. of CAE× 100)/(No. of Larvae+Cocoons CAE). *5 The number of parasitoids in the sample logs of Site No.1 was excluded.

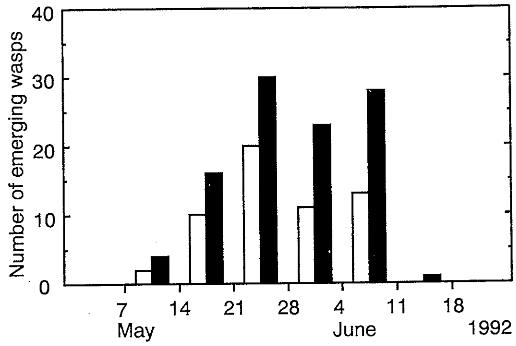

Fig. 2. Emergence pattern of the overwintered generation of *D. yogoi* from the sample logs which were collected in the autumn of 1991

Legend: □, Male; ■, Female.

sample logs of each study site. Percent parasitisms varied with the year; generally less in 1991 than in 1990 and 1992. The percentages of the *S. japonicus* larvae killed by unknown factors ranged from 10% to 30% (Fig. 3). Although three infestation levels of the *S. japonicus* on cedar trees, heavy, light and non-infested, were observed on the study sites (Table 1), the percent parasitism was not affected by the infestation level, that is, the percent parasitism even on a heavily infested sites was not so much.

On many sites, *D. yogoi* predominated in the parasitoid complex. In particular, it occupied almost all percentages on some sites (Sites Nos. 1, 3 and 4 in 1990 and Sites Nos. 1, 2, 9 and 10 in 1992); *I. sapporensis* was most abundant on a few sites (Sites Nos. 5 and 6 in 1990 and No. 8 in 1991), but this wasp was not collected from Site No. 1 throughout the three years. Furthermore, the percent parasitism of this species fluctuated greatly with the year even on the same site, such as in Sites Nos. 2, 4 and 5. Percent parasitisms of *A. initiator* and *S. brevicaudis* were both less than 10%.

IV. Discussion

D. yogoi was the predominate species in the parasitoid complex of the inoculated larvae of *S. japonicus*. In this study, there were two emergence times of this wasp species, May to June by the overwintered generation (Fig. 2), and July to August (Fig. 1). The emergence period of the overwintered generation was well-synchronized with the feeding period of *S. japonicus* larvae under the bark. Thus, overwintered adults of *D. yogoi* might have been able to utilize sufficiently the larvae of *S. japonicus* as a food resource for their

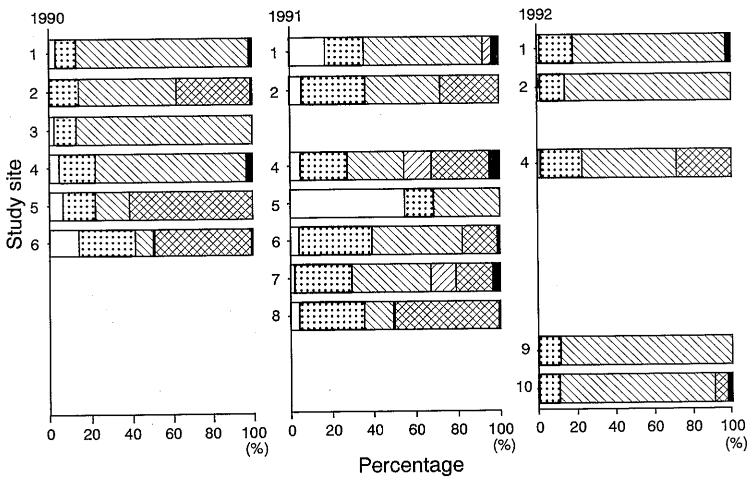

Fig. 3. Percentages of *S. japonicus* larvae which were parasitized by each parasitoid species in sample logs set on each study site shown in Table 1.

Legend: ▭, Unparasitized; ⁞⁞⁞, Larvae dead from some unknown factors; ▧, Parasitized by *D. yogoi*; ▨, Parasitized by *A. initiator*; ⊠, Parasitized by *I. sapporensis*; ■, Parasitized by *S. brevicaudis*.

offspring. Mature larvae of *S. japonicus* entered the wood from July to August to make pupal chambers 45~60 mm in depth from the bark surface (KOBAYASHI, 1982). We observed a few *S. japonicus* larvae which were parasitized by *D. yogoi* near the entrance of the larval galleries in the wood of cedar logs. However, the adults of *D. yogoi* emerging from July to August might not have used the larvae of *S. japonicus* in the wood because the mean length of their ovipositors was less than 5 mm (Table 3). Therefore, females of *D. yogoi* emerging in this season seemed to parasitize mainly another host species, *P. rufipenne,* whose larvae existed under the bark until later in the season than those of *S. japonicus*. Their offspring may overwinter in their cocoons and emerge in May or June of the next year.

I. sapporensis could not be collected on Site No. 1 (Kyoto) where debarking was done every two weeks in 1992, and hence the details of its life history were not detected except for its emergence period (Table 4); slightly earlier than that of *D. yogoi*. Furthermore, on Site No. 1 *D. yogoi* was the predominant species throughout the three years (Fig. 3). The offspring of the two species coexisted in the same sample logs, and their percent parasitisms fluctuated with the year on Site Nos. 2~8 (Fukui). Thus, *I. sapporensis* was distributed in Fukui but may not be so in Kyoto.

The percent parasitisms of *A. initiator* and *S. brevicaudis* were small (Fig. 3), although they are very common in pine forests (URANO and HIJII, 1991). These two species are not established in cryptomeria plantations, and they occasionally might take flight from pine forests and parasitize the larvae of *S. japonicus*.

On each study site, larvae of *S. japonicus* killed by unknown factors were observed (Fig. 3). When the eggs or larvae of the parasitoids were dead on the bodies of *S. japonicus*, it was difficult to determine the cause of the mortality. Thus, the real percent parasitism might be more than those shown in Fig. 3. In this study, a large proportion of the inoculated larvae were killed by the parasitoid wasps (Fig. 3). KATO (1991) also showed the large mortality of *S. japonicus* larvae by the parasitism of *D. yogoi* in dead trunks of cedar trees.

Adults of *S. japonicus* usually lay eggs under the bark of living trees, and most part of the young larvae are killed by resin flows between outer and inner barks (OKUDA, 1982; SHIBATA, 1987). Only a few larvae can survive under the bark. No parasitoid wasps were observed in the living cedar trees infested with *S. japonicus* (SHIBATA, 1987). There might be two possible reasons why parasitism on *S. japonicus* larvae have not been observed in living cedar trees. One is the death of parasitoid larvae which were caught in resin with their hosts; the other is the impossibility of parasitoids to search for their hosts in the living trees. MILLS *et al.* (1991) indicated that volatiles from the host gallery, including host frass and host gut components, are probably the proximal cues for host location by the parasitoids of Eurasian spruce bark beetles. Assuming that chemical cues may attract the parasitoids of *S. japonicus*, female wasps can search for their hosts even in the living tree because host frass and gut components can be found in living trees as well as in dead trees. Therefore, research on the oviposition and development of the parasitoids on *S. japonicus* larvae in living trees is needed.

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