

# A preliminary study on ecological features of two natural enemies against for two vectors of pine wilt disease for mass rearing in Korea

Moo-Sung Kim<sup>1</sup>, Bong-Woo Lee<sup>2</sup> and Jongok Lim<sup>3</sup>

<sup>1</sup>Korea National Arboretum, cindy5138@korea.kr

<sup>2</sup>Korea National Arboretum, eucosma@korea.kr

<sup>3</sup>Wonkwang University, limento21@wku.ac.kr

## Abstract

- Two species of the genus *Monochamus* (Coleoptera: Cerambycidae), *M. alternatus* and *M. saltuarius* are well-known vectors of pine wilt disease and cause economic damage in South Korea. Among various control methods to reduce the density of these vectors, use of biological control agents (natural enemies) is eco-friendly and essential.
- Since 2017, we carried out studies on parasitoid natural enemies of *M. alternatus* and *M. saltuarius* and found that two parasitoids, *Spathius verustus* Chao, 1977 (Braconidae) and *Cyanopterus flavator* (Fabricius, 1793) (Braconidae), have potential as biological control agents.
- We conducted a preliminary study on the life span and rate of parasitism of these two species with the two vectors as hosts. Both *S. verustus* and *C. flavator* had the longest mean adult life spans with *M. alternatus* as the host, at  $33.4 \pm 19.2$  days (at 30°C, RH 60%) and  $25.1 \pm 10.6$  days (at 25°C, RH 60%), respectively. Mean parasitism rate (62.5%) of *S. verustus* was highest in *M. alternatus* (at 30°C, RH 60%). In addition, it was confirmed that *S. verustus* can reproduce parthenogenetically.

## Introduction

- Biological control using natural enemies to control the density of pests has been conducted since 1920's and its diversity and potential for development are endless (Van Lenteren, 1995).
- Useful natural enemies is need to control the pine wilt disease (PWD) that has infested pine forest in South Korea.
- In 2020, the entomological team of the Korea National Arboretum found two useful parasitoids (*Spathius verustus* and *Cyanopterus flavator*) against two vectors (*Monochamus alternatus* and *M. saltuarius*) of PWD in Pohang, Gyeongbuk province, South Korea.
- As a preliminary study for using those parasitoids as natural enemies, we tried rearing them indoor. As results, we accumulated the fundamental ecological data of these two parasitoids.

## Material and Methods

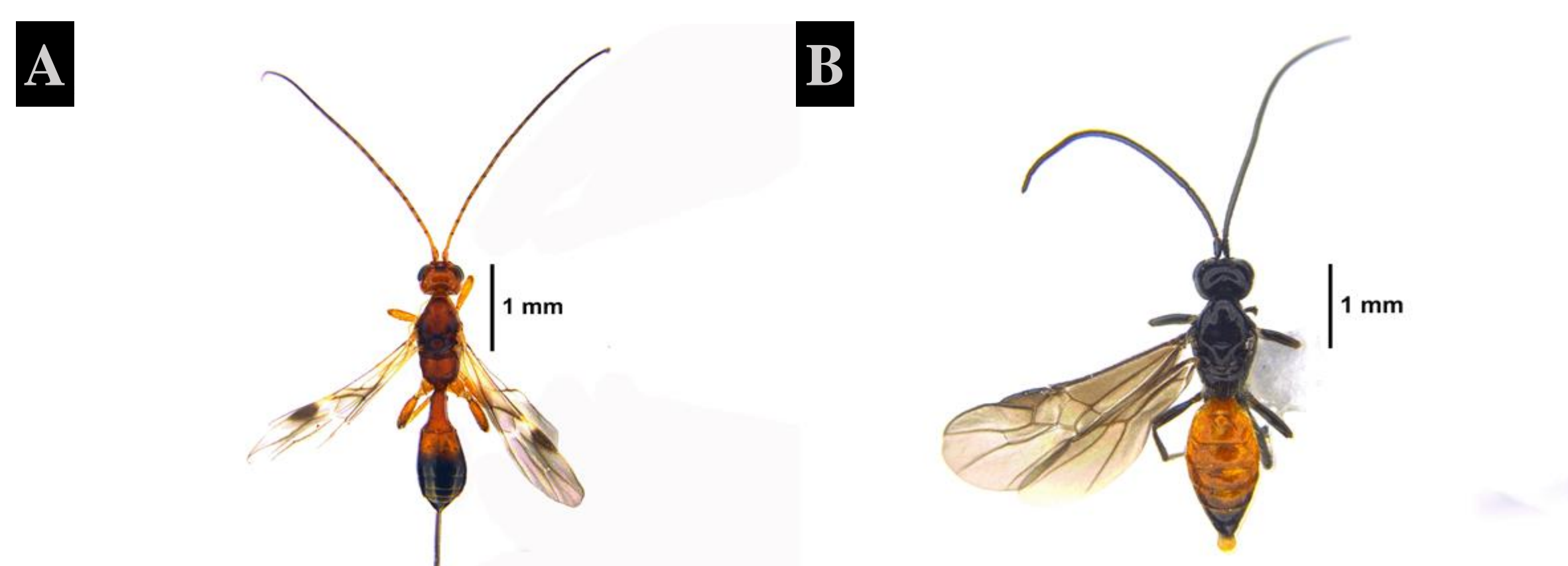


Fig. 1. Adult (female) habitus of *S. verustus* (A) and *C. flavator* (B) in dorsal view.



Fig. 2. Experimental methods and breeding experimental process. A, Investigation of parasitoids of vectors in infected area by PWD in Pohang; B, Collection of immature parasitoids on host larva; C, Rearing of parasitoids within sentinel logs in an growth chamber; D, Replacement of the sentinel log with the adult for every 14 days and dissection the log for investigation of the parasitism rate.

## Results and Discussion

- Cyanopterus flavator* is parasitic to two vectors of PWD *M. alternatus* and *M. saltuarius* in both 25°C (Tem.) / 60% (Hum.) and 30°C / 60%, and has a higher parasitism rate at a former condition. However, *C. flavator* is not parasitic on *M. alternatus* at 30°C / 60%.
- In addition, *S. verustus* is parasitic in both 25°C / 60% and 30°C / 60%. The parasitism rate is higher at 25°C / 60% and the highest parasitism rate is 93.33%. Investigation result of sentinel logs (No. 4-5, 7-5, and 8-5, *S. verustus* female can be parthenogenesis on *M. alternatus* and *M. saltuarius* (Table 1).
- At a condition of 25°C / 60%, *S. verustus* has a longer adult life span average (ave). than *C. flavator* but the parasitism rate ave. is low on the *M. alternatus*, same as *M. saltuarius* (Table 2). Adults of parasitoids could live on *M. alternatus* longer than on *M. saltuarius* and the overall parasitism rate ave. was higher on *M. saltuarius* than *M. alternatus*.
- At a condition of 30°C / 60%, *S. verustus* had higher adult life span ave. and parasitism rate ave. than *C. flavator* on *M. alternatus* (Table 2) In both *S. verustus* and *C. flavator*, females had a longer life span than males, and *S. verustus* had a greater difference than *C. flavator*.
- The adult life span ave. and parasitism rate ave. was longer and higher at 25°C / 60% than at 30°C / 60%. And while *S. verustus* lays up to five eggs, *C. flavator* lays only one egg per host (Table 2).

Table 1. Parasitism rates comparison of *C. flavator* and *S. verustus* at 25°C and 30°C.

Species	Temperature (°C) and Humidity(%)	Oviposition period	Sentinel log number	Host	No. of parasitised larvae	No. of host (larvae)	Parasitism rate (%)
<i>C. flavator</i>	25°C / 60%	Sep. 11-25	1-5(1♂, 1♀)	<i>M. alternatus</i>	8	8	100.00
			6-4(1♂, 1♀)	<i>M. saltuarius</i>	2	4	50.00
			14-3(1♂, 1♀)	<i>M. alternatus</i>	1	6	16.67
	30°C / 60%	Sep. 24-Oct. 8	1-6(1♂, 1♀)	<i>M. saltuarius</i>	2	5	40.00
<i>S. verustus</i>	25°C / 60%	Sep. 24-Oct. 8	2-5(1♂, 1♀)	<i>M. alternatus</i>	3	4	75.00
			8-6(1♂, 1♀)	<i>M. saltuarius</i>	14	15	93.33
			14-4(1♂, 1♀)	<i>M. alternatus</i>	2	3	66.67
		Oct. 8-22	2-6(1♂, 1♀)	<i>M. alternatus</i>	1	10	10.00
			4-5(1♀)	<i>M. alternatus</i>	1	7	14.29
			7-5(1♀)	<i>M. saltuarius</i>	3	13	23.08
	30°C / 60%	Oct. 22-Nov. 5	8-5(1♀)	<i>M. saltuarius</i>	4	13	30.77
			1-7(1♂, 1♀)	<i>M. alternatus</i>	1	3	33.33
		Nov. 6-20	2-7(1♂, 1♀)	<i>M. alternatus</i>	1	4	25.00
			4-6(1♂, 1♀)	<i>M. alternatus</i>	6	10	60.00
30°C / 60%	Sep. 24-Oct. 8	13-4(1♂, 1♀)	<i>M. alternatus</i>	4	4	100.00	
		15-3(1♂, 1♀)	<i>M. alternatus</i>	1	3	33.33	
		4-7(1♂, 1♀)	<i>M. alternatus</i>	1	7	14.29	
30°C / 60%	Nov. 6-20	16-5(1♂, 1♀)	<i>M. alternatus</i>	4	8	50.00	

Table 2. Ecological information of two parasitoids according to temperature-humidity and host (\*, number of used parasitoid adults for the present study).

Temperature (°C) and Humidity(%)	Host	Parasitoid	Sex	Adult life span Ave. (day)	Adult life span Max. (day)	Adult life span Min. (day)	Parasitism rate Ave. (%)	Number of oviposition per a host larva	N*	
25°C / 60%	<i>M. alternatus</i>	<i>S. verustus</i>	♂	26.3±9.5	39	22	-	-	10	
			♀	33.9±10.7	47	17	33.13	1~3	10	
	<i>C. flavator</i>	♂	25±10.4	33	9	-	-	17		
		♀	25.1±10.6	34	14	58.30	1	17		
	30°C / 60%	<i>M. saltuarius</i>	<i>S. verustus</i>	♂	24.7±6.3	34	10	-	-	7
				♀	32.5±8	52	16	49.06	1~3	7
<i>C. flavator</i>		♂	22.2±7	31	14	-	-	11		
		♀	21.9±7.3	34	16	50.00	1	11		
30°C / 60%	<i>M. alternatus</i>	<i>S. verustus</i>	♂	27.6±6.3	38	11	-	-	6	
			♀	33.4±19.2	68	7	62.50	1~5	6	
	<i>C. flavator</i>	♂	24.3±9.4	31	6	-	-	6		
		♀	25.2±9.4	32	11	40.00	1	6		
	<i>M. saltuarius</i>	<i>S. verustus</i>	♂	23.9±11.6	34	4	-	-	9	
			♀	23.4±12.5	39	6	40.00	1	9	