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## Survey on the Overwintering of Syrphids in Changbai Mountains and Experiments on Artificial Protection of the Overwintering Syrphid Flies

GAO Jun-Feng    ZHANG Guang-Xin    QIN Yong-Chun  
(Agricultural Extension Center of Tonghua County, Jilin 134100)  
YU Kai    LI Ming-Hai    QIN Yi  
(Agricultural Broadcasting College of Tonghua, Jilin)

In Changbai Mountains, there are about 130 days each year with an average temperature below zero. The ground is covered with snow for about 100 days each year and the lowest temperature could be as low as  $-35^{\circ}\text{C}$  during winter.

Under natural conditions, *Paragus quadrifasciatus* in the form of pupae overwinters in soil 4 centimeters beneath the surface. In the following year, these overwintering pupae hatch from mid-April to early May. Observations at fixed points in 4 different types of soil (sandy soil, black soil, southern hillside and northern hillside) were carried out continuously from 1988 to 1990 for three years. About 500 pupae of *P. quadrifasciatus* were released and protected at each point in late October. These points were covered with nets on April 15 of the following year and observed for the number of adult eclosion at an interval of 3 days. If the non-eclosion pupae were still alive on May 10, they were counted as eclosion pupae. The observed results are listed in Table 1.

**Table 1 Study on survival rate of *Paragus quadrifasciatus* in different overwintering sites under natural condition**

Site of observing	Year	Number of pupae (individual)	Number of incubated pupae (individual)	Survival rate (%)	The earliest hatching date (month • day)
Black soil	1988	487	114	23.4	4.27
	1989	500	105	21.0	4.29
	1990	500	213	42.6	5.3
Sand	1988	469	247	52.7	4.26
	1989	491	262	53.4	4.24
	1990	500	247	49.4	5.1
Southern slope of mountain	1988	500	231	46.2	4.21
	1989	500	243	48.6	4.22
	1990	482	264	54.8	4.24
Northern slope of mountain	1988	483	113	23.4	5.1
	1989	500	147	29.4	5.9
	1990	486	149	30.4	5.4

Data in Table 1 show that the mortality of *P. quadrifasciatus* pupae was related with overwintering sites. The survival rate of *P. quadrifasciatus* pupae was low in black soil and

northern hillsides, and eclosion adults emerged late too. Whereas, the pupae survival rate reached 50% in sandy soil and southern hillsides, and pupae were also hatched earlier.

Experiments on the protective overwintering of *P. quadrifasciatus* were carried out from 1990 to 1991. Cabbage was planted in sandboxes and inoculated with aphid in early August. Sandboxes were covered with nets in which adult *P. quadrifasciatus* was released in early September. Pupae of *P. quadrifasciatus* were formed in early October. When the outside temperature dropped to  $-5^{\circ}\text{C}$ , sandboxes were transferred to the following 4 different sites: 1) a basement; 2) an empty room; 3) ditches of 30 centimeters depth covered with woodblock and rice straw; 4) natural condition without any protection. The temperatures of basement and empty room were about  $-3^{\circ}\text{C}$  and  $-10^{\circ}\text{C}$  in winter. In mid April of the following year, sandboxes were removed from the above overwintering sites and put in the open air. The course of eclosion was observed and the results are listed in Table 2.

**Table 2 Research on survival rate of overwintering *Paragus quadrifasciatus* with artificial protection**

Site of overwintering	Year	Number of experiment (individual)	Number of incubated pupae (individual)	Survival rate (%)	Lowest temperature ( $^{\circ}\text{C}$ )
Basement	1990	472	397	84.1	-8
	1991	500	407	81.4	
Empty room	1990	500	386	77.2	-10
	1991	463	399	86.2	
Gouge outdoor	1990	500	312	62.4	-17
	1991	500	347	69.4	
CK	1990	500	247	49.4	-35
	1991	500	232	46.4	

Data in Table 2 indicates that *P. quadrifasciatus* overwintered better with artificial protection. The survival rates in the basement and empty room were both over 80%; whereas, the survival rate under natural condition was below 49%.

One hundred adult *P. quadrifasciatus* hatched from different overwintering conditions were further observed for their sex ratio, longevity, and the number of eggs laid. Results are recorded in Table 3.

**Table 3 Observation on adults of *Paragus quadrifasciatus* that hatched under different overwintering conditions**

Site of overwintering	Sex ratio	Average longevity (day)	Average number of egg /individual	The highest number of egg/individual	Longest longevity (day)
Basement	1:1.1	31.0	114	187	37
Empty room	1:1.1	30.5	117	157	34
Gouge outdoor	1:1.7	27.0	84	112	30
CK	1:2.3	24.0	72	103	27

The results in Table 3 indicate that the overwintering conditions not only influenced the survival rate of *P. quadrifasciatus*, but also markedly affected the longevity, egg numbers laid

per adult *P. quadrfasciatus*, and sex ratio of the hatched adult *P. quadrfasciatus*.

The results of our study showed that artificial protection during overwintering not only increased the numbers of *P. quadrfasciatus* in the fields in the following year, but also improved their quality, which may help in the control of aphids.