SHORT COMMUNICATIONS

Seasonal Fluctuation and Spatial Pattern of the Adult Population of the Japanese Pine Sawyer, *Monochamus alternatus* HOPE (Coleoptera : Cerambycidae), in Young Pine Forests¹

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Adults of the Japanese pine sawyer, *Monochamus alternatus* HOPE, emerged from dead pine trees, carry the Japanese wood nematode, *Bursaphelenchus lignicolus* MAMIYA et KUYOHARA, which causes pine wilt. They seek the branches of healthy pine trees for their maturation feeding (MAMIYA, 1972). During this feeding, the nematodes enter the vascular tissue of the trees. Adults of the sawyer oviposit successfully on the weakened or trees newly killed by nematodes (MORIMOTO & IWASAKI, 1972). The serious pine wilt of the Japanese red pine, *Pinus densiflora* S. et Z., and the Japanese black pine, *P. thunbergii* PARL, intensified by this cooperation of the sawyer and the nematode, spread so widely in Japan that the annual volume of trees killed in 1979 exceeded 2 million cubic meters.

To elucidate the epidemic mechanism of this wilt, some workers (MORIMOTO et al., 1974; MORIMOTO et al., 1975; YOSHIDA et al., 1978) studied adult populations collected by bait logs or chemical substances. Those populations, however, consist of ovipositing adults but not those feeding on healthy trees. Hence, this paper describes the seasonal fluctuation and spatial pattern of adult populations on healthy trees in young pine forests.

This study was carried out in a young Japanese black pine forest with an area of about 0.27 ha at Kose, Gose City, Nara Prefecture. This forest, surrounded by paddy fields and young forests of Hinoki cypress (*Chamaecyparis obtusa* S. et Z.), was planted in 1972. The mean diameter of trees at breast height was 7.7 cm and the mean height

was 4.2 m in 1978. Tree mortality from pine wilt in this forest was 48% in 1977 and 61% in 1978.

Seventy healthy trees in a limited area (20 m × 20 m) of the forest were chosen for a census in 1978, while all healthy trees (97) in the forest were examined in 1979. Healthy trees were distinguished from weakened ones by examination, for oleoresin exudation at each sampling time. Twenty-three censuses were done from early June to early September in 1978 and 28 censuses from late May to early September in 1979.

After a sheet of cloth (3.6 m × 4.5 m) was spread on the ground around a tree, the tree was shaken continuously 30 times. All adults which fell on the sheet were collected and then released on the same tree after marking for identification. One spot on the pronotum and/or eight spots on the elytra of each adult were marked with lacquer paint in four colors. In mid-May in 1978 and 1979, logs of trees infested the previous year were introduced into the cage in the Experiment Station in order to study the emerging pattern of adults.

Fig. 1 shows the seasonal fluctuations of adults collected. The total number was 560 in 1978 and 380 in 1979. The maximum number per census was 70 (1.0 per tree) in 1978 and 54 (0.6 per tree) in 1979. Though when adult emergence began in 1978 was not known because of the delayed start of the study, the seasonal trends of the fluctuation in both years were quite similar. A comparison of the seasonal fluctuation of adults with the emergence curve obtained in the cage in 1979 showed that the first collection in the forest agreed approximately with the beginning of emergence in the cage (late May) and also the peaks of both curves coincided with each other about mid-June (Fig. 1). Therefore, adults seem to have appeared in this forest starting in the end of May in 1978 as in 1979.

The sex ratio of adults collected was approximately 0.5 (Fig. 1), the same as that of adults emerging in the cage. This ratio was higher than that estimated from the populations collected by means of bait logs and chemical attractants (MORIMOTO et al., 1974; MORIMOTO et al., 1975). It may be considered that the author's method may determine the sex ratio with more accuracy than other methods.

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Fig. 1. Seasonal fluctuations of the number (●—●) and the sex ratio (○---○, solid circle ; significant at 0.05) of adults collected in the young forest, and the number of adults emerging from logs settled in the cage (—).

Fig. 2. Seasonal fluctuations in the number of adults estimated by JOLLY-SEBER's method. Vertical lines shows the standard deviations.

By JOLLY-SEBER's method (JOLLY, 1965; SEBER, 1972), the number of adults on healthy trees was estimated from late May to early July when adults were abundant. It increased after early June and reached a peak in the middle of June (Fig. 2). MORIMOTO (1977) pointed out that besides the abundance of dead host trees for adult oviposition, mortality from intraspecific competition among larvae under the bark of the host tree would mainly determine the abundance of the sawyer the next year. In this study, the mortality of larvae, estimated from the difference

between the numbers of egg scars and emergence holes left on the logs introduced into the cage the preceeding year, was similar in both years (96.4% in 1977, 97.9% in 1978). Furthermore, the number of egg scars per 1 m² on the logs was much the same (16.0 in 1977, 16.7 in 1978). However, the number of dead trees in this forest was 229 in 1977 and 151 in 1978. The decreased number of adults in 1979 might have been caused by the decrease of dead trees the previous year.

The spatial pattern of the adult population on healthy trees which is expressed by the rela-

tionship between the mean (m) and the mean crowding (m^*) of the number of adults collected per tree (IWAO, 1968) shows that adults were distributed in a clumped pattern ($m^*=0.105+1.808m$, $r^2=0.505$). Combined data for 1978 and 1979). Larger trees would not tend to attract more adults because no significant correlation was recognized between the size of individual trees and the total number of adults collected from them. KOBAYASHI et al. (1973) and IDO et al. (1976) found that emerging adults tended to feed mainly on healthy trees neighboring the trees from which they emerged. Thus, the clumped distribution of the sawyer population might be mainly due to the feeding habits of emerging adults.

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Appendix. ESTIMATES OF ADULT POPULATION BY JOLLY-SEBER'S METHOD

Date	i	n _i	m _i	s _i	$\hat{\alpha}_i$	$\hat{M}_i$	$\hat{N}_i$	$\hat{\phi}_i$	$\hat{B}_i$	$\sqrt{\hat{V}(\hat{N}_i)}$	$\sqrt{\hat{V}(\hat{B}_i)}$	$\sqrt{\hat{V}(\hat{\phi}_i)}$	$\sqrt{\hat{V}(\hat{N}_i/N_i)}$
1978	Jun.	6	1	46				2.435				1.445	
		7	2	39	0.205	112.0	546.0	0.206	45.9	366.5	61.1	0.143	369.1
		8	3	43	0.186	29.5	158.6	0.560	416.8	87.3	287.4	0.303	87.2
		13	4	70	0.071	36.1	505.6	0.904	530.1	317.1	543.0	0.490	317.2
		14	5	54	0.093	91.4	987.1	0.273	362.7	651.1	456.4	0.136	651.1
		20	6	33	0.061	38.3	632.0	1.732	-334.3	475.1	813.7	0.847	474.9
		21	7	38	0.158	120.0	760.0	0.783	-75.7	444.4	263.1	0.498	444.7
		22	8	48	0.229	119.0	519.3	0.220	65.8	301.1	64.8	0.127	301.1
		30	9	42	0.191	34.3	179.8	0.383	25.9	87.1	34.5	0.161	86.6
		Jul. 3	10	29	0.276	26.1	94.7	0.743	34.7	40.4	43.9	0.367	39.7
		6	11	15	0.333	35.0	105.0	1.333	175.0	59.5	177.9	0.903	59.1
		9	12	21	0.191	60.0	315.0	1.390	-73.9	229.7	250.3	1.523	229.6
		13	13	17	0.294	107.0	363.8			387.0			387.1
		17	14	12	0.583								
1979	May	31	1	4				1.025				0.390	
		Jun. 4	2	21	0.095	4.1	43.1	0.969	75.8	26.6	59.3	0.333	26.6
		7	3	21	0.191	22.4	117.5	0.780	240.1	61.9	147.7	0.255	61.9
	Jun.	11	4	54	0.093	30.7	331.7	0.929	-71.2	154.0	138.1	0.254	153.9
		13	5	48	0.313	74.1	237.1	1.072	22.4	75.8	67.2	0.554	75.4
		15	6	53	0.415	114.8	276.4	0.281	181.9	140.8	161.7	0.182	140.6
	Jul.	18	7	19	0.158	41.0	259.7	0.526	-66.7	186.4	81.8	0.344	186.3
		20	8	21	0.429	30.0	70.0	0.274	46.0	40.9	35.5	0.169	39.9
		22	9	17	0.177	11.5	65.2	0.850	12.7	40.4	33.8	0.519	40.2
	Jul.	25	10	22	0.318	21.7	68.1	0.900	202.7	43.1	319.2	0.964	42.8
		27	11	8	0.125	33.0	264.0	0.388	-32.6	361.7	106.7	0.430	361.7
		30	12	9	0.222	15.5	69.8			64.1			63.6
	Jul.	2	13	11	0.455								

n_i: Number of adults captured at the (i)th sampling. m_i: Number of adults with mark captured at the (i)th sampling. s_i: Number of adults released after marking at the (i)th sampling. $\hat{\alpha}_i$: Proportion of marked adults captured at the (i)th sampling. $\hat{M}_i$: Total of marked adults available in the population before the (i)th sampling. $\hat{N}_i$: Total of adults available in the population before the (i)th sampling. $\hat{\phi}_i$: Survival rate of adults between the (i)th and the (i+1)th sampling. $\hat{B}_i$: Number of adults joined between the (i)th and the (i+1)th sampling. $\sqrt{\hat{V}(\hat{N}_i)}$, $\sqrt{\hat{V}(\hat{B}_i)}$, $\sqrt{\hat{V}(\hat{\phi}_i)}$ and $\sqrt{\hat{V}(\hat{N}_i/N_i)}$: Standard deviations for N_i, B_i, $\hat{\phi}_i$ and N_i/N, respectively.