Seasonal Changes and Spatial Patterns of Adult Populations of the Sugi Bark Borer, *Semanotus japonicus* LACORDAIRE (Coleoptera: Cerambycidae), in Young Japanese Cedar Stands

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Seasonal changes and spatial patterns of adult populations of the sugi bark borer, *Semanotus japonicus* LACORDAIRE, which attacks the trunks of Japanese cedar and cypress were determined using a simple banding technique developed by the author. Adults emerged from the trees from March 20 to April 15. Population size based on a mark-release-recapture method was estimated. The spatial distribution patterns of collected adults per tree and daily occurrence of emergence holes were both contagious. This contagious pattern results from lack of dispersal of adults throughout the stands; very little movement of the adults from tree to tree was observed.

INTRODUCTION

The sugi bark borer, *Semanotus japonicus* LACORDAIRE, attacks trunks of Japanese cedar, *Cryptomeria japonica* D. DON, and Japanese cypress, *Chamaecyparis obtusa* S. et Z.. Though trees are seldom killed by its attack, the commercial value of the timber is severely reduced by the damage called "Hachikami", the scars and rot caused by larval feeding and subsequent invasion of wood rotting fungi (KOBAYASHI, 1980). In spring, emerged adults lay eggs in bark crevices. Hatched larvae feed on the phloem and cambium. Full-grown larvae enter the wood in late summer, pupate in pupal cells in autumn and overwinter as adults.

Many studies on the biology of this pest and "Hachikami" damage have been published during the past twenty years. Adult populations in cedar or cypress stands, however, have not been investigated in detail because it is not easy to find and collect adults even in severely infested forests. I devised a simple method of collecting adults and sampled throughout the emergence and flight period to determine seasonal changes and spatial patterns.

STUDY AREA AND METHOD

This study was carried out in two young Japanese cedar stands, near Takatori, Nara Prefecture in 1981. Site A was a stand of 17-year old cedars, approximately 130 m² in area; site B located about 150 m from site A and consisted of 8-year old trees in an area of 500 m². The mean diameters of trees at breast height in site A and B

were 11 cm and 10 cm, respectively. The "Hachikami" damage has been observed in site A, but not in site B in which only new emergence holes were observed for the past few years.

In site A, all trees (94) were examined, while in site B 27 trees were chosen for the census in a limited area (4 m × 4 m). Thirty-two censuses were done from March 19 to May 9 in site A and 10 censuses were done from April 1 to 24 in site B.

It is well known that adults prefer to hide themselves in shaded locations on the trunks. For sampling, therefore, the stem of each tree was loosely wound round with a double layer of polyethylene black netting (degree of shade: 70%) about 10 cm wide, at ground level and 1.2 m above the ground. All adults in the bandage were collected, marked for identification, and then released on the same bandage. In site A, emergence holes newly observed at each census were counted and marked with paint.

RESULTS

Seasonal changes of adult population

More adults were collected in the bandages at 1.2 m above the ground than at ground level in both sites (Table 1). No adults were found elsewhere on the trunks

Table 1. Total number of adults collected in the same bandages at 1.2 m above the ground and the ground level at each site

	1.2 m above ground			Ground level		
	Male	Female	Total	Male	Female	Total
Site A	304	167	471	148	69	217
Site B	51	42	93	13	5	18

Fig. 1. Seasonal changes in emergence holes (□—□), collected adults (●—●) and number of adults estimated by JOLLY-SEBER's method (○—○, vertical lines: standard deviations) in site A and B.

at any census.

Figure 1 shows the number of adults collected in each site and new emergence holes found in site A in each census. In site A, new unmarked emergence holes were found from March 20 to April 15 and more than 20 adults were collected in each census in the same period. After April 15 the number of adults reduced gradually, and no adults were found after May 9. The sex ratio in the two sites was not significantly different (0.34 in site A; 0.42 in site B). The maximum number per census was 38 (0.4 per tree) on April 10. By JOLLY-SEBER's method (SEBER, 1973) based on mark-release-recapture data, population size of the adults in site A was estimated. It increased after late March and reached a peak in the early April (Fig. 1).

Spatial distribution pattern of adult population

In order to analyze the seasonal changes in spatial distribution pattern per tree per day of collected adults in both sites and emergence holes in site A, $\bar{m}^*/\bar{m}$ value as an index of aggregation (IWA0, 1968) was calculated (Fig. 2). $\bar{m}^*/\bar{m}=1$ when the distribution is random, $\bar{m}^*/\bar{m}>1$ when the distribution is more or less contagious, and $0<\bar{m}^*/\bar{m}<1$ when the distribution is uniform.

In site A, $\bar{m}^*/\bar{m}$ values of collected adults on trees were very high on March 20 and 21 when the adults began to emerge. Subsequently they decreased to a relatively constant level greater than 1. In site B, for the period sampled, $\bar{m}^*/\bar{m}$ values were similar to those in A. Values of $\bar{m}^*/\bar{m}$ of emergence holes at each census in site A were also very high at the beginning of emergence, and also decreased gradually, but showed consistently higher values than that of the collected adults. It is obvious that contagion is high at the time of emergence and decreases as a result of dispersion but a generally contagious pattern is maintained.

Movement of adults within the stand

The mark and recapture study showed that adults tended to be re-collected more often in the same bandage of the same tree than in any other (Fig. 3). When the adults were not captured on the same tree, they were found more often in trees within 2 m (Fig. 4). Therefore, it seems that the adults of this species tend to remain on the same trees, and disperse only short distances within the stand.

Fig. 2. Seasonal changes in $\bar{m}^*/\bar{m}$ values of collected adults on trees (site A: ●—●, site B: ○—○) and newly emergence holes (site A: △—△). Thin line shows $\bar{m}^*/\bar{m}=1$.

Fig. 3. Locations of recaptured adults. Upper figure: ▨-% adults recaptured in the same tree; □-% recaptured in other trees. Lower figure: Adults collected in the same tree. ▨-% adults recaptured in the same bandage at 1.2 m; ■-% recaptured in the same bandage at ground; □-% recaptured in different bandage.

Fig. 4. Frequency distribution of distances between trees in which the same adults were collected at the two successive censuses.

DISCUSSION

Seasonal changes of adult emergence in cages have been investigated in detail. The beginning of emergence from logs in cages is in mid or late March and emergence is completed by early May in Kinki District (HOSODA and KOBAYASHI, 1979; KOBAYASHI et al., 1981). In this investigation, emergence occurred always at the same time as in cages but adults were present in the stand for about a month after emergence was completed (Fig. 1). This fact should be considered when undertaking control of this species.

The movement of adults from tree to tree was rare in the stand (Figs. 3, 4), in

contrast to adults of the Japanese pine sawyer, *Monochamus alternatus* HOPE which are more active in the forest (SHIBATA, 1981). That is, adults of the pine sawyer seek the branches of healthy pine trees for their maturation feedings and oviposit successfully on trees weakened or newly killed, mainly by pine wood nematode, *Bursaphelenchus xylophilus* NICKLE (MAMIYA, 1972; MORIMOTO and IWASAKI, 1972). Adults of the sugi bark borer, however, need not feed for maturation, and are able to mate and oviposit on the bark of trees soon after they emerge, which may account for their lack of dispersion.

Although adults of this species tend to oviposit more often on rough bark than smooth, such preference of the adults was not detectable in this study, because there was no clear difference in the roughness of the bark on the study trees.

Spatial distribution pattern of collected adults per tree was similar to that of daily occurrence of emergence holes in site A (Fig. 2). The contagious distribution of the emergence holes would be reflected by that of the previous adults. In any case, spatial distribution pattern of adults per tree appears to be determined by the extent of their movement (Figs. 3, 4).

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