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The Role of Non-Dispersers in the Population Dynamics of *Adelges japonicus* MONZEN (Hemiptera: Adelgidae) in an Ezo-Spruce Plantation¹

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Adelges japonicus MONZEN infests spruce, especially *Picea jezoensis* CARRIÈRE in Hokkaido. Several reports on the biology of *A. japonicus* have been published (INOUE, 1940; YANAGISAWA, 1942; KOUNO, 1942), but there are few reports on the population dynamics of the insect except one on the life table for the 2nd generation of a population (KAMATA et al., 1984).

Adelges japonicus has two generations a year. Nymphs of the 1st generation appear from late September to early October. After overwintering, they molt three times to become wingless females (=fundatrices) which lay eggs at the basal part of a bud. These individuals of the 1st generation never leave the place where they settled in autumn.

The 2nd generation nymphs appear from mid-

to late May, and crawl into buds swollen due to the stimulus given by the fundatrices (KAMATA and YOSHIDA, 1985). Those buds then mature into galls, and last instar nymphs emerge from the galls in August, molt into winged female adults, and most of them disperse to other trees. In a *P. jezoensis* plantation, it was observed that some alatae did not disperse and laid eggs on the needles around the galls from which they had emerged. These alatae (non-dispersers) seemed to play an important role in the population dynamics of the insect. This paper describes their role in maintaining or increasing the population density in a plantation.

Studies were done at Hitsujigaoka experimental forest of the Forestry and Forest Products Research Institute. The plantation was 0.5 ha in area, and in 1973, 1,482 saplings were planted 1.8 m apart. The aphid invaded in 1980.

On 21 September 1983, one sample branch was chosen from each of 36 sample trees and the numbers of alatae which had oviposited there were counted. Branches on which non-dispersers had laid egg masses were excluded from the sample branches. However, when oviposition sites of non-dispersers (non-disperser's sites) were found, the number of sites and number of galls in that site were counted.

Each sample tree was stratified horizontally into three and vertically into four, for a total of 12 sampling area. The number of buds and aphids

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Fig. 1. The relation between the number of galls formed in 1983 and 1984 on each tree. (a): on the trees on which non-dispersers oviposited ($n=7$), (b): on the trees on which non-dispersers did not oviposit ($n=29$). Number indicates the number of trees.

in each area was counted. Such a count was repeated on 18–23 November 1983, and 1–7 and 18–20 May 1984.

The mean number of galls formed on a tree was 6.4 (S.D.=11.7) in 1983 and 28.4 (S.D.=72.4) in 1984. Twenty-four and 20 out of the 36 sample trees bore galls in 1983 and 1984, respectively; there were 10 which did not bear galls in either year. The value of $\bar{m}/m$ (Iwao and Kuno, 1968) was 4.3 and 7.9 in 1983 and 1984. Thus, galls distributed aggregatively in this plantation, and the aggregativeness increased in 1984. The relationship between the number of galls formed in 1983 and 1984 on each tree is shown in Fig. 1. The number of galls increased greatly on 7 trees, 6 of which had been oviposited by non-dispersers. The maximum increase in the number of galls on a tree was 285, and the maximum ratio of the number of galls in 1984 to that in 1983 was 24.1.

Inspecting egg masses around galls, it was estimated that non-dispersers emerged from 41 galls in 1983. This was 19% of the total galls, and their distribution was aggregative ($\bar{m}/m=11.5$). Twenty-two of the 41 galls were formed on one tree. On this tree the percentage of galls from which non-dispersers emerged was 34%, signifi-

Fig. 2. Relative survivorship curve for 1st generation of *Adelges japonicus*. (a): on oviposition sites by non-dispersers, (b): on 12 sample branches of trees where non-dispersers oviposited, (c): on 12 sample branches of trees where non-dispersers did not oviposit.

cantly different from that on the other trees ($P < 0.01$).

The mean number of alatae that oviposited on one tree was estimated to be 57.6 in 1983, and the mean number of eggs laid by an alate was 32.5 ($n=301$, S.D.=6.8). Therefore, the mean number of eggs laid on a tree was estimated to be 1,852. More than 100 nymphs are expected to have emerged from a gall about 1.5 cm in length (INOUE 1940). In comparison with the number of alatae expected to have emerged in this plantation, those which actually laid eggs was very small: 9.0 per gall from which they had emerged. Among the alatae which oviposited 97.1% of them were non-dispersers. The mean number of non-dispersers laying eggs in a non-disperser's site was 42.8.

Relative survivorship curve of the aphids on non-disperser sites, on the sample branches of trees on which non-dispersers had oviposited and on other trees are shown in Fig. 2. It is interesting that the number of nymphs on the branches on which non-dispersers oviposited decreased before mid-November. The decrease was very small from mid-November to May, but became large in May. Though more eggs were oviposited in this plantation by non-dispersers than by dispersers,

Fig. 3. Percentage of infested buds to all buds. (a): on oviposition sites by non-dispersers, (b): on 12 sample branches of trees where non-dispersers oviposited, (c): on 12 sample branches of trees where non-dispersers did not oviposit.

the total number of nymphs found in non-dispersers' oviposition sites was much fewer than that found in others after November 18. On trees where non-dispersers laid eggs, though the number of nymphs on non-dispersers' oviposition sites decreased after September 21, the number on other branches actually increased slightly in the same period. This means that many nymphs left the non-dispersers' oviposition sites for other branches. Thus, the number of galls increased throughout the trees. Compared to these trees, the number of galls on other trees was small and the percentage of infested buds to total buds was also extremely small (Fig. 3).

Figure 4 shows the relationship between the number of buds infested by the aphids on 18–20 May 1984 and the number of galls found the following summer. The trees where more buds had been infected in May bore more galls that year. It was difficult to distinguish the fundatrices of *A. japonicus* from those of *Aphrastasia pectinatae* var. *ishiharai*. Of the galls found in 1984, 88.1% were those of *A. japonicus*. Therefore, it was estimated that 43.4% of the buds infested by *A. japonicus* in spring bore galls that year.

Extreme tree-to-tree variation is found in the number of galls formed in a *P. jezoensis* plantation.

Fig. 4. Relation between the number of buds infested by the aphids on 18–20 May 1984 and the number of galls of *Adelges japonicus*.

Some trees are always lightly infested or uninfested even in heavily infested stands. It is confirmed that the galls on the heavily infested trees are due to non-dispersers. Non-dispersers are considered to play a very important role in increasing the aphid population density in a plantation of *P. jezoensis*.

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