Insecticide-Application Effects on the Emergence of the Glassy-Wings, Conipia hector Butler : Lepidoptera : Aegeriidae

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Insecticide-Application Effects on the Emergence of the Glassy-Wings, *Conipia hector* Butler (Lepidoptera : Aegeriidae)

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Introduction

The glassy-wings, *Conipia hector* Butler (Lepidoptera: Aegeriidae), is one of the serious pest insects of cherry species. This moth is univoltine, and the hatched larvae bore into the bark and feed on the fresh inner bark, the phloem, and cambium of trunks and branches, of cherry trees (Kobayashi 1977; Taketani and Kobayashi 1994). Adding to the direct damage given to cherry trees by this moth, more susceptilility to pathogens such as *Armillaria* root rot, *Armillaria mellea*, and *Valsa* canker, *Valsa japonica*, is to be induced to the severely attacked trees.

Tama Forest Science Garden of the Forestry and Forest Products Research Institute (Hachioji, Tokyo) have preserved a collection of cherry trees consisting of at least 1800 individuals of nearly 250 varieties from various parts of Japan. Those have been planted in the Cherry Tree Preservation Forest (later only the Preservation Forest) since 1966. In recent years, a lot of cherry trees in the Preservation Forest were attacked by the moth (Fujita *et al.* 1988; Minai and Iwata 1988) in addition to other pests and diseases, showing symptoms of abatement in vigor (Ishii *et al.* 1989). Therefore, by using pheromone traps Tama Forest Science Garden conducted the survey of adult emergence and at the same time applied smithion in order to depress the moth population.

In this paper, I describe the results of the survey of the adult emergence of the moth made for a total of 9 years and discuss the smithion-application effects on the moth population with special references to the multi-annual changes and the spatial variations in the number of the captures per trap.

The parts of the data of the captures during 1983 to 1985 have already been reported by Minai and Iwata (1988).

Methods

This study was conducted in the Cherry Tree Preservation Forest of Tama Forest Science Garden, the Forestry and Forest Products Research Institute, during the period from 1983 to 1993. The Presevation Forest is about 6 ha in area, located on steep slopes (25-35° in inclination), and surrounded by the secondary forests of broad-leaved trees, such as *Quercus glauca*, *Q. myrsinaefolia*, *Q. serrata*, *Castanopsis cuspidata*, *Camellia japonica* and so on, mixed with *Abies firma* and *Torreya nucifera*. In this Preservation Forest, about 1800 cherry trees consisting of 250 varieties were planted together with native trees of *Acer palmatum*, *A. cissifolium*, *Q. myrsinaefolia*, and *Camellia japonica*.

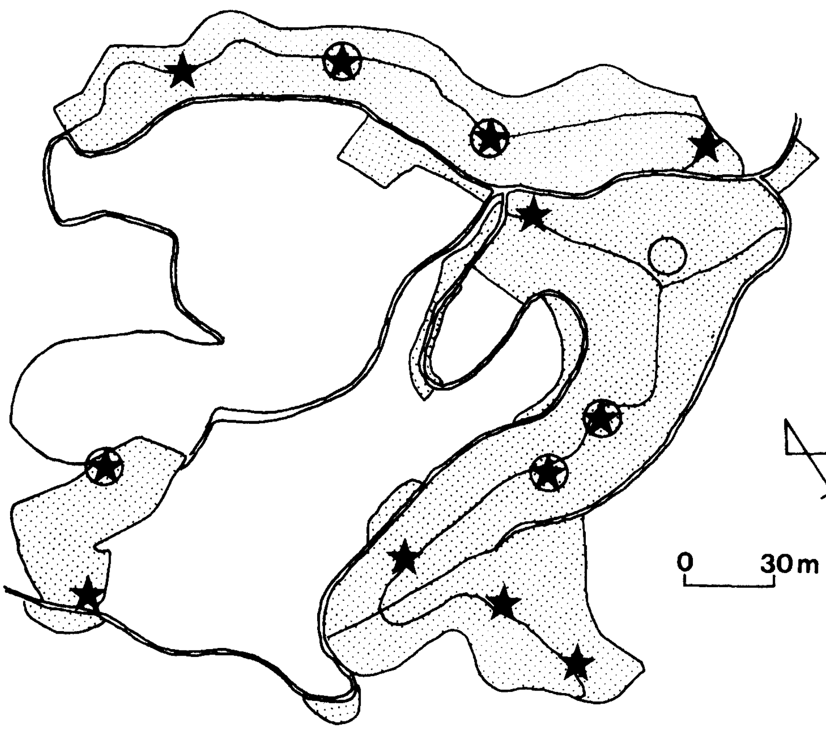

Fig. 1. Location of pheromone traps in the Cherry Tree Preservation Forest (Dotted areas).
○: Traps from 1983 to 1985. ★: Traps from 1988 to 1993.

The emergence of the moth was surveyed by using pheromone traps. A trap was made of a plate whose upper surface was coated with viscous substance and furnished with a roof (Pherocon TM, Zoëcon Corp. California). A rubber cap soaked with female sex pheromone (the mixture of (Z,Z) - 3, 13 - and (E, Z) - 3, 13 - octadecalienyl acetate at the ratio of 1 : 1) (Pheromone Otsuka for the glassy-wings, Asu Chem. Corp.) was set on the upper surface of the plate. Six and 12 traps were set throughout the Preservation Forest from 1983 to 1985 and from 1988 to 1993, respectively (Fig.1). Those were hung on to the branches of cherry trees 1.5 m above the ground. The number of adult males caught by each trap was counted every two weeks, or occasionally, at the intervals of 10 days or one month, during the period from May to December every year. The pheromone-soaked rubber caps were changed every two months and plates were replaced *ad libitum*.

In order to depress the population density of the moth, 400 ml of 50-times dilution of smithion (MEP) was sprayed on the trunk(s), up to 2 m above the ground, of the respective trees. Smithion was applied in mid-July, just before the peak of the adult emergence, up to 1989. After 1990, smithion was applied only every three years for labor saving, and after two years of interruption in 1992, smithion was sprayed in May, just before the beginning of adult emergence, and in July (Table 1).

Results

1. Seasonal and multi-annual changes

Table 1 shows the mean numbers of male moths canght per trap. The mean number of male moths caught decreased consistently from 36 to 8.6/trap from 1983 to 1989 when

Table 1. Annual changes in the mean number of captures per trap and its patchness indices.

Year	Mean	Var.	Patchness index	No. of traps	Application of insecticide
1983	36.0	10.7	1.05	6	July
1984	24.0	12.9	1.20	6	July
1985	26.2	8.1	1.04	6	July
1988	16.1	8.9	1.22	12	July
1989	8.6	7.0	1.49	12	July
1990	12.0	7.9	1.32	12	No
1991	12.6	7.9	1.28	12	No
1992	13.0	4.8	1.05	12	May, July
1993	4.5	4.8	1.83	12	No

smithion was being applied every year. In 1990, smithion was not applied and the mean number increased to 12/trap. But the difference in the mean numbers between the year of 1989 and that of 1990 was not significant (F=1.245, P>0.05). After keeping the relatively constant values from 1990 to 1992, it decreased significantly in 1993 (F=18.815, P<0.01), probably due to unusual weather condition during the summer in 1993 (low temperature, few sunny days, and much precipitation).

Fig.2 shows the seasonal changes in the numbers of captures of male moths for nine years. The capture of male moths started in mid-May through early June, showed a small peak in June through July and a large peak from mid-August through mid-Sepetmber, and ceased in mid-October through mid-November. The number of male moths caught during the early half of the season gradually decreased and the date when the cummulative number of moths caught reached the 50 % of the tatal captures, shifted from late July to early September (Fig.3). Consequently, the peak became more apparent in August and September throughout the study period.

2. Spatial patterns

The spatial variations of the capture of male moths in the Preservation Forest were examined by the patchness index (the ratio of the mean crowding ($\overset{*}{m}$) to the mean (m) of the total number of the male moths caught per trap; $\overset{*}{m}/m$). The mean and the mean crowding were calculated as follows;

$$m = \sum_{i=1}^{q} x_i / q$$

$$\overset{*}{m} = \sum_{i=1}^{q} x_i(x_i-1) / \sum_{i=1}^{q} x_i$$

where x_i is the number of moths caught in ith trap and q is the number of traps (Lloyd 1967). Although the values of the patchness index were nearly equal to unity in the respective three years (1983, 1985, and 1992), they were greater than unity in all the years (Table 1). These results suggest that the capture of the male moths among traps was more or less aggregative.

The spatial pattern of the capture of the moths was also analysed by examining the series of $\overset{*}{m}$-m ralationship in the number of male moths caught on each census occasion (Iwao

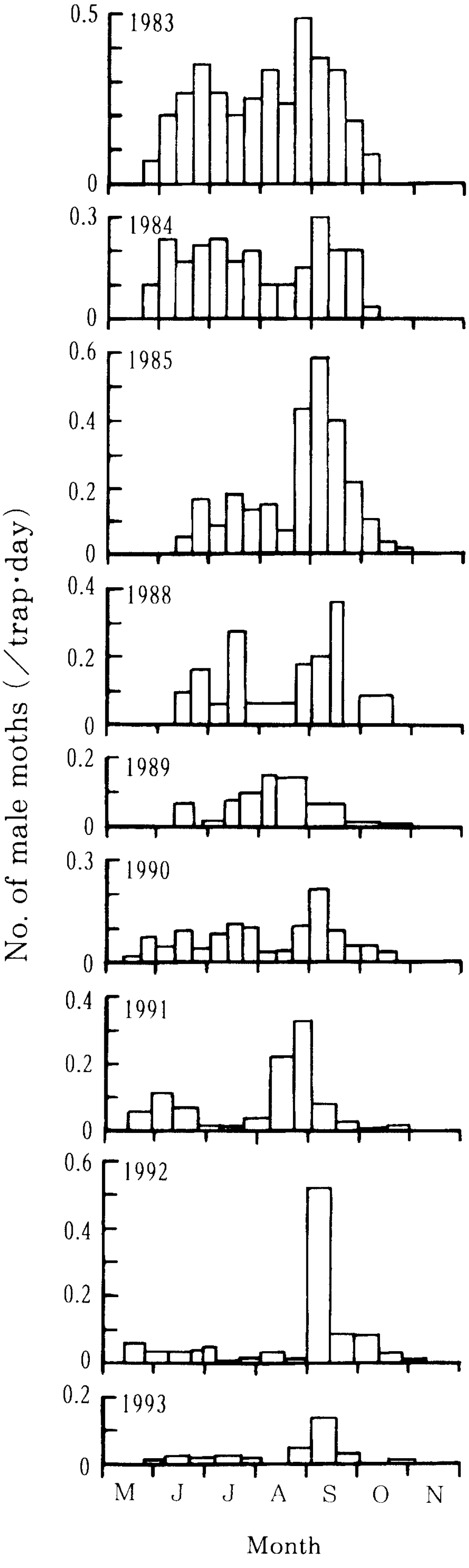

Fig. 2. Seasonal changes in the number of male moths caught by all the traps.

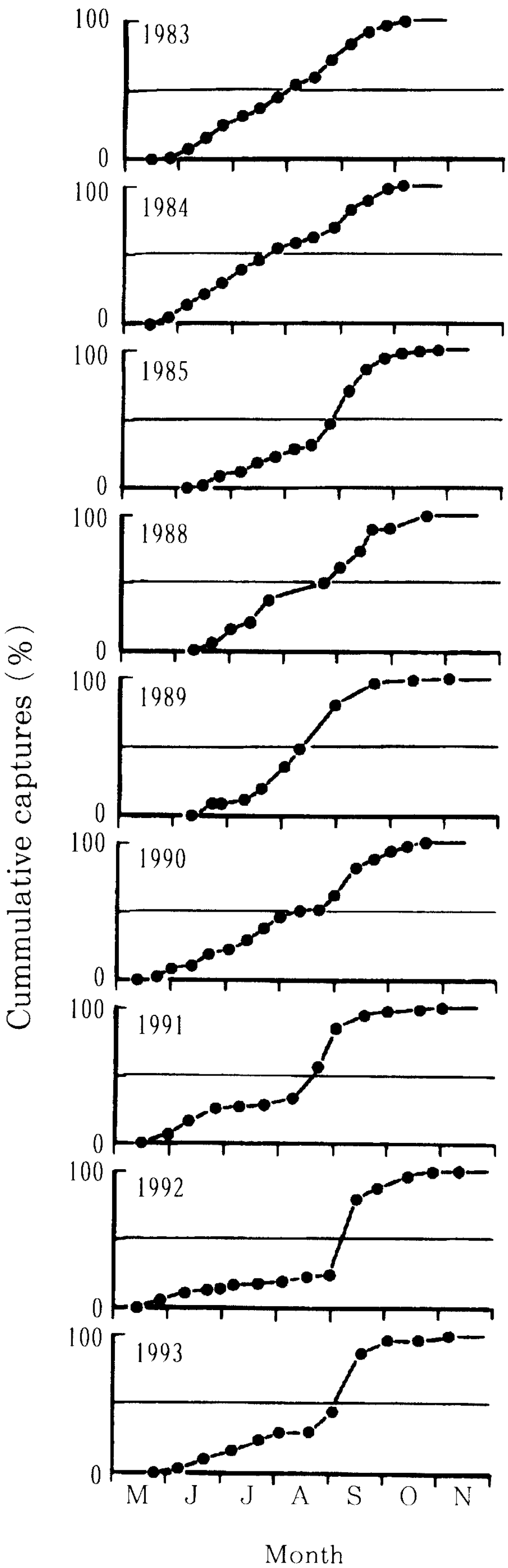

Fig. 3. Cummulative number(%) of male moths captured.

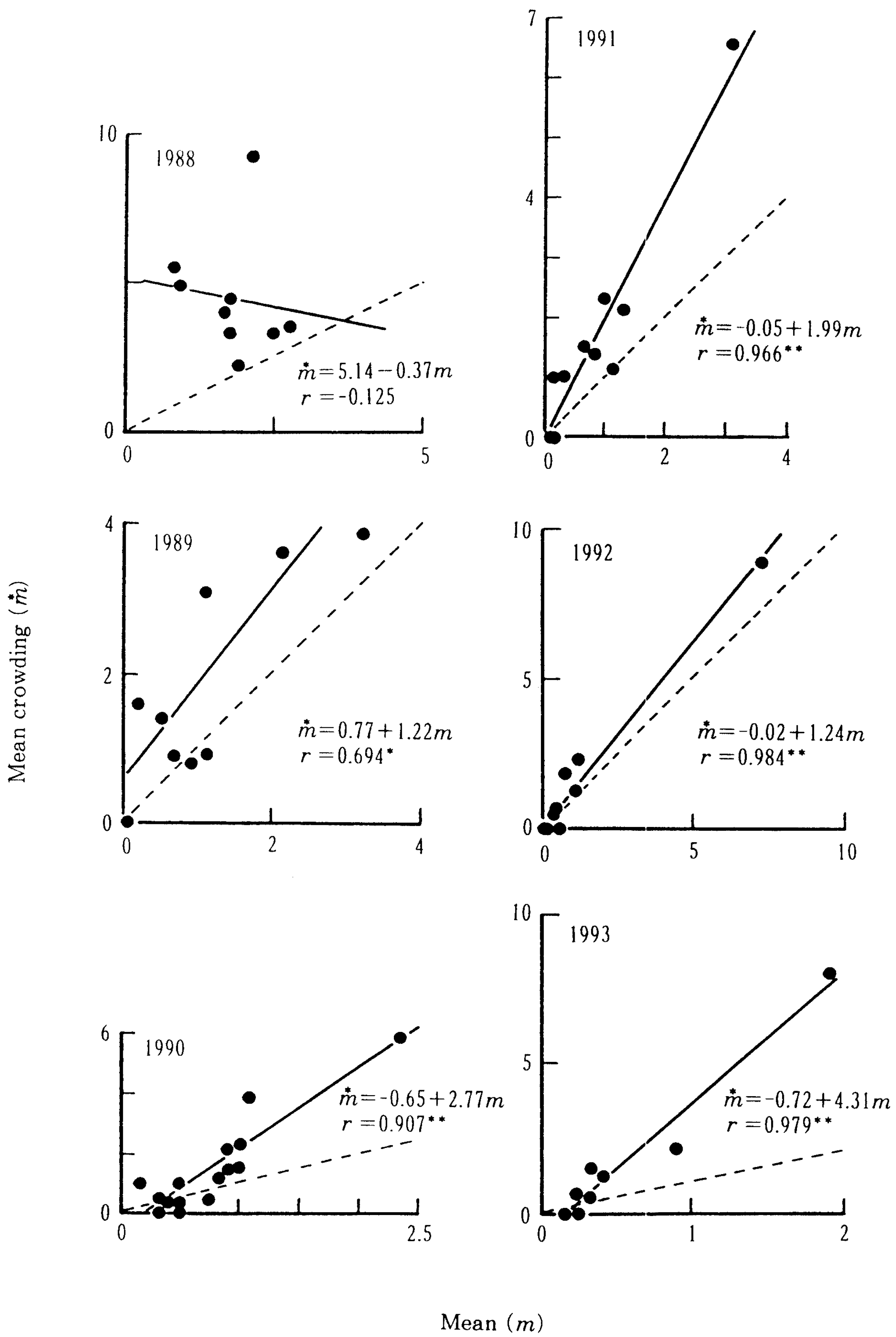

Fig. 4. The series $\overset{*}{m}$-m relationships in the number of male moths caught on each census occasion.

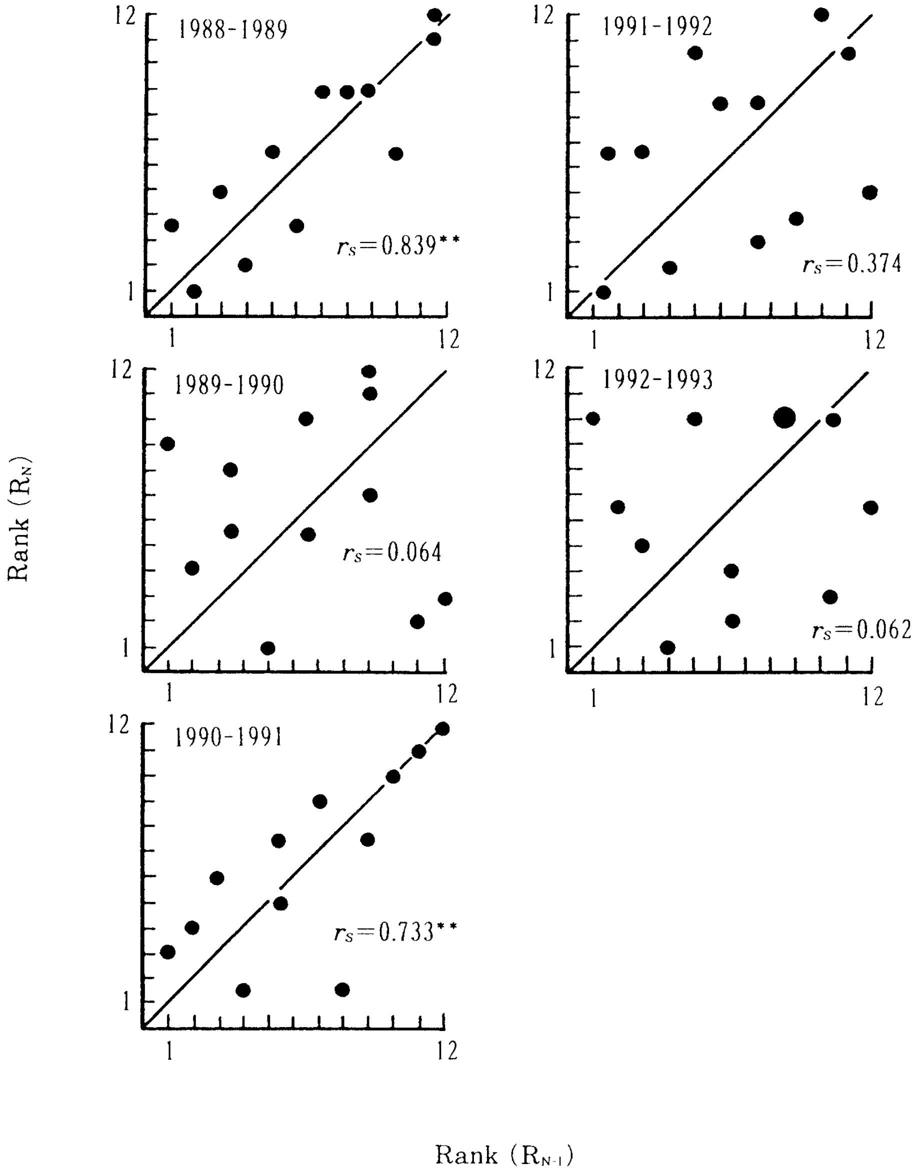

Fig. 5. The Spearman's rank correlation between the number of male moths caught by each trap in the successive years.

1968).

Fig.4 shows the $\overset{*}{m}$-m relationships for six years. In 1988, there was no significant relationship between them, suggesting no consistent pattern of the local distribution in the capture of the moth on each census occasion. However, significant possitive regressions were obtained in 5 other years. The values of the slope (β) were greater than unity and those of the intersection (α) did not differ from zero through all five years. These results show that the pattern of the captures of male moths in the Preservation Forest was aggregative, and that male moths were caught independently from each other. The slopes of the regression line were steeper in 1990, 1991, and 1993 when smithion was not applied, than those in 1989 and in 1992 when smithion was applied.

In order to examine the annual changes in the spatial pattern of the captures of male moths, the numbers of male moths caught in each trap during the successive years were analyzed by the Spearman's rank correlation coefficients (r_s) (Sokal and Rohlf 1981). Significant positive correlations were obtained between 1988 and 1989 and between 1990 and 1991 (Fig.5). In the former, smithion was applied in both years, and in the latter, smithion was not applied in both years (Table 1). In the other three cases in which smithion was applied in one year of the pair (Table 1), there was no significant correlation between them (Fig.5).

Discussion

Pheromone traps and traps with chemical attractant are often used in estimating the number of insects which are active fliers (Yanbe *et al.* 1985; Nakai *et al.* 1994; Kondo and Tanaka 1994). An effective range of the trap to which objective insects are attracted may be influenced by weather conditions, such as wind. If the capture of insects on one trap is to be affected by other traps, it turns out that the number of captures on each trap does not give any valid indications of the population density and of the spatial distribution pattern of the individual insects. Nakai *et al.* (1994) set traps with chemical attractant for adult pine sawyers, *Monochamus alternatus*, in the two adjacent stands of pines and metacequoiya, standing about 10 m apart from each other, and caught much more number of pine sawyers on traps in the pine stand. In the present study, pheromone traps were set more than 30-40 m apart from each other (Fig.1). Although insects react to quite small amounts of pheromone (Tamaki and Yagi 1990), it may be highly probable that the capture of the moth by each trap was carried out independently from each other in the present study.

Adult males of the moth were captured during the period from May to November, showing a large peak in August through Sepetmber through the whole years. From 1983 to 1991, the number of captures showed a small peak also in June and July. These seasonal patterns of the captures were similar to those reported by Kobayashi (1977) and Taketani and Kobayashi (1994). The presence of these two peaks suggests the possibility that the moth may have two generations a year as Taketani and Kobayashi (1994) stated.

In the Preservation Forest, smithion was sprayed on only the trunks situated up to 2 m above the ground, and it could not act on the moth which had attacked the higher trunks and branches. However, the attacking of the moth is to be observed more frequently at root color and on trunks situated up to 50 cm above the ground (Soné in preparation). Therefore, the application of smithion can give severe impacts on the moth population even if it is applied once a year. The consistent declining from 1983 to 1989 in the total number of male moths caught supports this conclusion. The decline in the number of captures for the early half of the season, namely the disappearence of the first peak in June and July, is responsible for the considerable parts of the decline in the total number of captures. Smithion was applied between the first and the second peaks, in mid-July. Tabata and Okubo (1980) detected 0.02 ppm of smithion on the pine twigs 3 months after the spraying. Therefore, it was assumed that smithion could act both on larvae and pupae in trunks that were going to emerge after the spraying and on larvae from eggs deposited by females that had emerged before spraying. But I could not clarify how application of smithion changed the mortality rate of each developmental stage of the moth.

Both in 1990 and in 1991 when smithion was not applied, the number of moths caught did not increase conspicuously. These results suggest that 7 successive years' application of smithion was effective on the depression of the moth population for at least two years after ceasing of the application. The fact that the number of moths caught in 1992 when the application of smithion resumed was similar to those observable in 1990 and 1991 suggests two possibilities about the smithion application effects on the moth population. First, smithion application counteracted the increase of the moth population. Second, the moth population could not increase significantly due to the smithion application executed successively until 1989, and smithion applied in 1992 did not induce significant effects on the moth population. But I could not determine which was the actual case.

The spatial distribution pattern in the capture of moths was more or less aggregative. The differences in the susceptabilities to the attack of the moth among varieties (Fujita *et al.* 1988, Soné unpublished data) might have contributed to this aggregative tendency. The smithion-application also affected the spatial distribution patterns in the emergence of moths. Although there was no distinct difference in the mean number of the moths caught respectively in 1990, 1991, and 1992, the spatial distribution pattern in the capture of moths was obviously less aggregative in 1992 than in 1990 or 1991 (Table 1, Fig.4). The smithion-application in 1992 disturbed the positive rank correlation in the number of captures per trap between the year of 1990 and that of 1991 when smithion was not applied (Fig.6). This was partly due to the depression of the moth emergences in the local areas in which more moths had emerged in the previous year, and this depression might have decreased the degree of aggregativeness in the emergence of adults in 1992.

Summary

The emergence of adult males of the glassy-wings, *Conipia hector*, was surveyed in the Cherry Tree Preservation Forest of Tama Forest Science Garden, Hachioji, Tokyo, during the two periods, the one from 1983 to 1985 and the other from 1988 to 1993. The number of male moths caught decreased consistently by smithion-application executed for successive years. The smithion-application disturbed the spatial distribution pattern in the emergence of moths and decreased the degree of aggregativeness in the spatial distribution patterns of the captured moths.

Acknowledgement

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