JARQ 24, 149–155 (1990)

Ecology of *Hypsipyla grandella* and Its Seasonal Changes in Population Density in Peruvian Amazon Forest

Saburo YAMAZAKI, Akihiko TAKETANI, Kazuyuki FUJITA, Carlos VASQUES P.* and Toshiya IKEDA

Abstract

Hypsipyla grandella is the most harmful insect pest against Meliaceae, including Cedrela spp. and *Swietenia macrophylla*, in the tropics of the South American region. Field surveys on damages and bionomics of H. *grandella* conducted in the Peruvian Amazon area under the Forest Regeneration Experiment Project during the period 1983 to 1987 revealed that the population density of H. *grandella* increased rapidly in the rainy season, i.e. September or October to May. There were some cases where the damage ratios exceeding 50% had resulted in failures in establishing plantations because of the repeated attacks by high density population of H. *grandella*. The availability of feed stuffs for this species increased in the rainy season, while decreased in the dry season. The seasonal change of H. grandella density was closely correlated with that of newly sprouted host trees. *C. odorata* was more susceptible to H. *grandella* attack than S. *macrophylla* was. Natural enemies identified were several parasitic wasps, a few predatory wasps, a nematode, ants and fungi. Both wasps may greatly contribute to control H. *grandella* in nature. Mixed planting with other tree species than Meliaceae was not successful in reducing insect damages in line plantations. Since *Hypsipyla* adults seem to prefer young plants of the host species, planting in clear cut areas may help them identify their host trees for mating and laying eggs. Therefore, in is not advisable to employ clear cutting of more than 5 m-width or clean weeding in plantation. Planting in a small patch may be worth of testing. Natural regeneration under spot planting with shading by a forest canopy would give some effect on reducing the insect attack, though the tree growth may be reduced.

Discipline: Insect pest
Additional key words: Cedrela odorata (Cedro), mahogany shootborer, Swietenia macrophylla (Caoba)

Introduction

A number of useful tree species in the Peruvian Amazon area have seriously deteriorated in terms of amount and genetic resources as well in the last several decades. At present, the population of the following three most valuable trees, i.e. Caoba (*Swietenia macrophylla*, mahogany in English), Cedro (*Cedrela odorata*) and Ishipingo (*Anburana cearensis*), is very small in size because of extensive and selective cuttings, burning and great difficulties in natural regeneration. Therefore, the current prices of these lumbers are very high, reflecting their wide uses for furniture, architecture and durable goods. On the other hand, the prices of other kind of trees have also been gradually rising in recent years. Taking into account this situation, the Peruvian Government has been making efforts in promoting regeneration of degraded secondary forests or depressed forests[6].

The Forest Regeneration Experiment Project in Peruvian Amazon started in 1982 under the aid program of the Japan International Cooperation Agency (JICA). The objective of the project was to develop forest regeneration technology which should include

Forest Biology Division, Forestry and Forest Products Research Institute (Tsukuba, Ibaraki, 305 Japan)
* National Institute of Agriculture (Pucallpa, Peru)

an effective utilization of the existing natural forest resources in Peru by demonstrating afforestation of experimental forests[9].

Twenty seven species of useful trees were selected and planted for the regeneration experiment. The tree species planted had generally been in good shape of growth both in height and volume in the first stage of the project. However, the most serious incidence took place thereafter. It was the destructive outbreaks of three Meliaceae species, i.e., *S. macrophylla*, *C. odorata* and *Cedrela fissilis* (Cedro blanco), caused by the attack of mahogany shoot borer, *Hypsipyla grandella* Zeller.

Matsui, M.[9] and Kobayashi, K. et al.[7] outlined the damage of Meliaceae spp. and the biology of *H. grandella*, and emphasized the urgent necessity of further studies on biology and control method of *H. grandella*.

During the period 1986 to 1987, intensive studies were undertaken with major emphasis placed on biology, population dynamics and control method of *H. grandella* under cooperation of the Peruvian and Japanese scientists[12]. The present report accounts for the results of the studies on population dynamics and ecology of *H. grandella* in relation to its host trees.

Forestry in Peru

Forest areas in Peru are divided into three geographic groups; i.e., coastal zone, mountain zone and Amazon forest zone. The forests in the Amazon forest zone predominate, consisting of tropical rain forests.

The forests in each zone are further classified into natural forest, artificial forest and forest to be regenerated (Table 1). Approximately 88% of the total forest land is covered by a natural forest, but its ratio to others is decreasing very rapidly. The forest to be regenerated is mainly located in the mountain zone (71%) and partly in the Amazon forest zone (24%) and the coastal zone (5%). Further regeneration or plantation is expected in the mountain zone, where a majority of the artificial forest (92%) has already been established with successful plantations of eucalyptus. In the Amazon forest zone, on the other hand, the forest to be regenerated is still limited at present. This is not attributed to a shortage of suitable land for regeneration but to a lack of technology for regenerating the degraded secondary forest after migration farming or selective cuttings. The forests in the watershed of the Amazon cover an area of about 40 million ha, which is the richest forest in Peru with a variety of trees. Eighty percent of lumber production consists of only a few species, i.e. *Cedrela* sp. (40%), *Swietenia* sp. (13%) and *Podocarpus* sp. (11%). However, utilization of other species has been expanding in recent years owing to the development of wood processing technologies[6].

Table 1. Forest area in Peru

(1000 ha)

Zone	Natural forest	Artificial forest	Forest land to be regenerated	Total
Coastal zone	950	8	493	1,451
Mountain zone	50	98	7,402	7,550
Forest zone	73,000	8	2,498	75,506
Total	74,000	114	10,393	84,507

Six species in the genus *Hypsipyla* have been identified in the world. Among them, two species, *H. robusta* Moore and *H. grandella* Zeller, predominate in large areas, giving serious damages to Meliaceae species. The distribution of these two species is shown in Fig. 1[1,8].

Study sites and design of planting

While the Pacific coast area of Peru has an extremely small precipitation, the inland area beyond the Andes has much more precipitation, being covered by tropical rain forests. The study site is located in Von Humboldt National Forest, approximately 80 km west of Pucallupa in the Peruvian Amazon area.

Annual rainfall in the project area is approximately 4,000 mm. A great portion of the rainfall concentrates during the period October to April; monthly rainfall sometimes exceeds 800 mm. Approximately 700 ha of the forest land in the National Forest was included for planned management under the project, comprising 580 ha for plantation, 80 ha for natural regeneration, and 40 ha for demonstrated plantation. A half each of the experimental forest land was plain and hilly. The study sites for plantation and demonstration were both selected in the

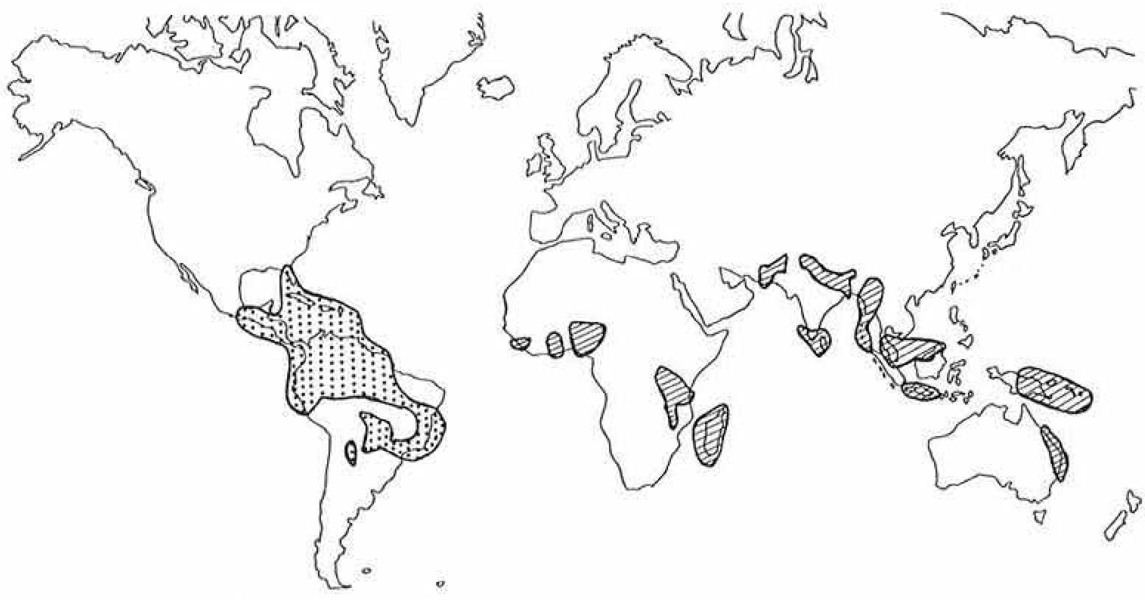

Fig. 1. Geographycal distribution of *Hypsipyla grandella* (dotted) and *H. robusta* (oblique lines)

plain area and those for natural regeneration were in the hilly area.

Entomological studies were undertaken mainly in the plantations, where either *C. odorata* or *S. macrophylla* dominated. Line plantations with 100–200 m length were subjected to three types of clear cuttings, i.e. 5, 10 and 30 m in width. These types were set up to evaluate an effect of shading on tree growth as well as on alleviation of the damage caused by *H. grandella*. In the clear cutting area with 5 m-width, young trees of either *Cedrela* or *Swietenia* were planted in every 5 m on the middle of line. In the 10 m-width plantation, either species above was planted in every 10 m, being surrounded by four other trees but Meliaceae with an aim of protecting it from the attack of *Hypsipyla*. In 30 m-width plantation, five seedlings of either *Cedrela* or *Swietenia* were planted in every 5 m on a line, and seedlings of other tree species were planted alternatively in two or three consecutive lines. This design was employed with the same purpose of protecting Meliaceae from *H. grandella* attack[2,3].

In addition to field surveys on damages, biological studies on *H. grandella* were conducted in the laboratory.

Ecology of *Hypsipyla grandella* Zeller

Eggs are white for one day after oviposition, turn yellow in two days, reddish yellow in three days, and then hatch. The duration of each larval stage which compasses five or occasionally six instars is approximately 5 days and that of prepupa through pupa is about 10 days, and the adult survives for 5–7 days. One generation of *H. grandella* is approximately one and half month long, inducing six to seven generations a year.

Their inhabitation ranges from the top shoot to the base of young trees, but rarely to the roots. The upper part of seedlings is inhabited mainly by young larvae and the lower part by elder larvae or pupae. This indicates that larvae migrate downward on a young tree as they grow up. The eggs are separately laid on both surfaces of new leaves in general. However, if the seedlings have few or no foliages, the eggs are laid on a stem, where newly produced frasses are excreted nearby.

As well known, adult females prefer young trees for their inhabitation due to the attractants released from new leaves. The females release a pheromone in mating with males[5].

Host plants

Hypsipyla spp. is closely associated with trees or shrubs of *Meliaceae* family. The host trees of *Hypsipyla* spp. recorded so far include: *Cedrela mexicana* (=*blanco*), *C. odorata, Chloroxylon swietenia, Chukrasia tabularis, Entandophragma angolense, E. utile, Khaya anthotheca, K. grandifoliola, K. ivorensis, K. nyasica, K. senegalensis, Lovoa trichilioides, Swietenia macrophylla, S. mahogany, Toona australis, T. ciliata* and *T. serrata*[4,5].

Natural enemies

Natural enemies so far identified are: a parasitic nematode (Fam. Mermithidae), two parasitic wasps (*Bracon* sp., *Trichogramma* sp.), and a fungus (*Beauveria* sp.). Among them, a nematode, presumably *Hexamermis albicaus* (Nicle and Grijpma, 1974), shows the highest parasitoid against *Hypsipyla* larvae; the larval parasitism sometimes exceeds 10%. *Trichogramma* sp., an egg parasite, gives 10% or less in its parasitism. The eggs parasitized by *Trichogramma* sp. change their color from red to black. Role of *Bracon* sp. and *Beauveria* sp. as a mortality agent is rather limited. Several hunting wasps which belong to Family Vespidae and Hymenoptera are observed quite often to drum on the tree shoot, searching for the larvae of *Hypsipyla*. Therefore, the role of the wasps as a control agent may probably be very important.

Damages of Meliaceae spp. in plantations and other regeneration areas

Intensive surveys on infestation levels were conducted during the period 1985 to 1987 to compare implications of tree species, size of trees and planting methods (Table 2). The two Meliaceae spp., each of which was planted in line plantations, were subjected to comparison in regard to the damages caused by *Hypsipyla* spp. The damage ratio in Cedro plantations was 24%, whereas that in Caoba was 11%. These early damages, which took place within 1–2 months after the *Hypsipyla* moved in, were much less than those of the accumulated damages for the following 2–3 years.

A comparison of the damage ratios in line plantations among different widths of clear cuttings indicated that the 10 m-width plantation received the most serious damages, followed by the plots with the width of 30 m and 5 m. The smallest damage in the 5 m-width plantation might have probably resulted from a greater crown coverage of neighboring trees over the young Meliaceae than the case in 10 m-width. In 30 m-width plntations, there was also a great coverage of surrounding trees which grew faster than Meliaceae did. However, such a difference in coverage by canopy was not large enough to clearly justify the damage variation and evaluate the planting methods as well.

The surveys were also conducted in other three areas in addition to the line plantation areas (Table 2). The damage ratios in these areas were all less than those in the line plantations; in particular, the ratio in the natural regeneration area was very small or 5% only. The coverage of surrounding trees on the canopy over the young Meliaceae spp. was generally greater in these areas than in the line plantation area. In this respect, a few explantations could be made to justify the difference of damage ratios. First, the small ratio might be caused by the lack of new foliages of Meliaceae for female adult moths to lay eggs on due to the less light intensity. Second, it might be associated with the barrier effect of surrounding trees for females to search for their host plants. The line plantation areas, on the other hand, might provide a more suitable space for adult females

Table 2. Damage ratios in various regeneration areas (1985–87)

Planting method	No. of trees under surveys	Damaged ratios of host plants (%)
L.P.[1]		
5 m w.	10,377	16
10 m w.	3,304	26
30 m w.	5,673	19
P.C.[2]	1,668	10
Spot[3]	194	13
N.R.[4]	22	5
Cedro[5]	62,83	24
Caoba[5]	6,182	11

1): Line planting on clearly cut area with the width of 5, 10 and 30 m, 2): Planting under canopy, 3): Spot planting, 4): Natural regeneration, 5): Damage ratios were investigated on the stands where only a single species of either Cedro or Caoba was planted.

to search for their host plants and for males to meet females to copulate.

In the natural forest, where a light thinning accompanied by planting of some seedlings under the canopy was made in 1983, no infestation of *Hypsipyla* was observed on both Cedro and Caoba in the first year. In the second year, only two plants of Cedro out of 19 in that plot were infested, while the infestation in the line plantation areas were much more serious. In contrast with this, in the forest which received heavy thinning, most of the Cedro young trees planted in 1984 were heavily attacked in the following succesive two years. Growth rate of the young Meliaceae plants in the lightly-thinned forest was almost the same to that in the line plantation area in the first year, but it reduced considerably in the second year. In the heavily-thinned forest, on the other hand, new growth was vigorous.

With a view to reducing the damages of young Meliaceae caused by *Hypsipyla*, regeneration of Meliaceae under the canopy of other trees is expected to be effective. Particularly, Caoba would grow high enough to escape from the attack of *Hypsipyla* under the canopy, providing that its growth rate is not as fast as that in open areas.

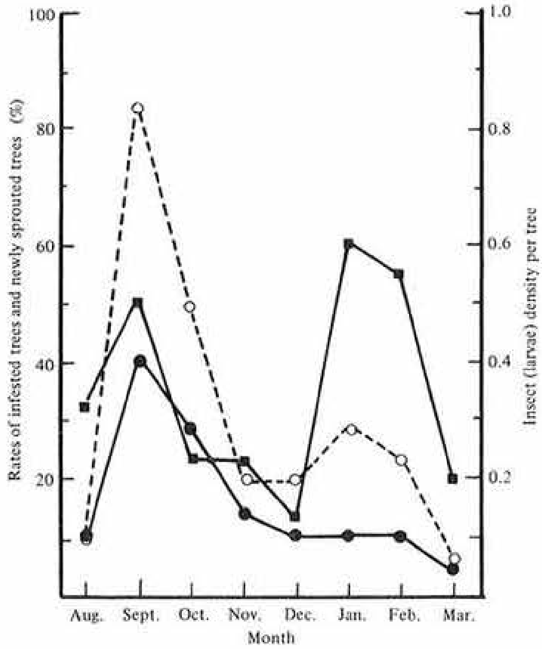

Fig. 2. Seasonal patterns of the rates of the infested trees (●), the newly sprouted trees (■) and the insect density (○)

Seasonal changes of tree damages and *Hypsipyla* population density

A survey was carried out in the experimental field which had been grown to Cedro seedlings after clearcutting to analyze the relationships of the infestation level in the host plant and the density of *Hypsipyla* with availability of its oviposition sites, i.e. newly sprouted trees. The investigation was made during the period the end of the dry season to the end of the rainy season (Fig. 2). In September when a rainy season started, the first peak of new sprouting came out, accompanying an increasing population density of *Hypsipyla* as well as a rapid expansion of damaged trees. In addition to the close correlation between the seasonal changes of *Hypsipyla* densities and the damage ratios throughout the period up to March, both of these changes were also closely correlated to the change of the number of newly sprouted trees from August to December, but not thereafter up to March (Fig. 2). In the latter half of the rainy season, another great increase of newly sprouted trees did not induce the corresponding increase of *Hypsipyla* density and the damage ratio of host plants.

In plantation areas, the damage ratio of Cedro and Caoba started increasing from the beginning of the rainy season, usually September (Fig. 3). It reached the maximum level in October resulting from accumulated reproduction, thereafter it gradually decreased by the end of the rainy season. During the dry season, the population density was maintained generally at a low level. However, it sometimes increased to some extent due to the occasional rainfall for a short period, thereby another small peak of infestation was induced in a year. The damages in Cedro were always greater than in Caoba throughout the year.

In regard to the interaction between the population density of *H. grandella* and its host species, it might be explained as follows:

(1) At the beginning of the rainy season, the host trees are in ideal conditions for *Hypsipyla* to increase its density.
(2) During the rainy season, the oviposition sites are abundantly available, but the infestation

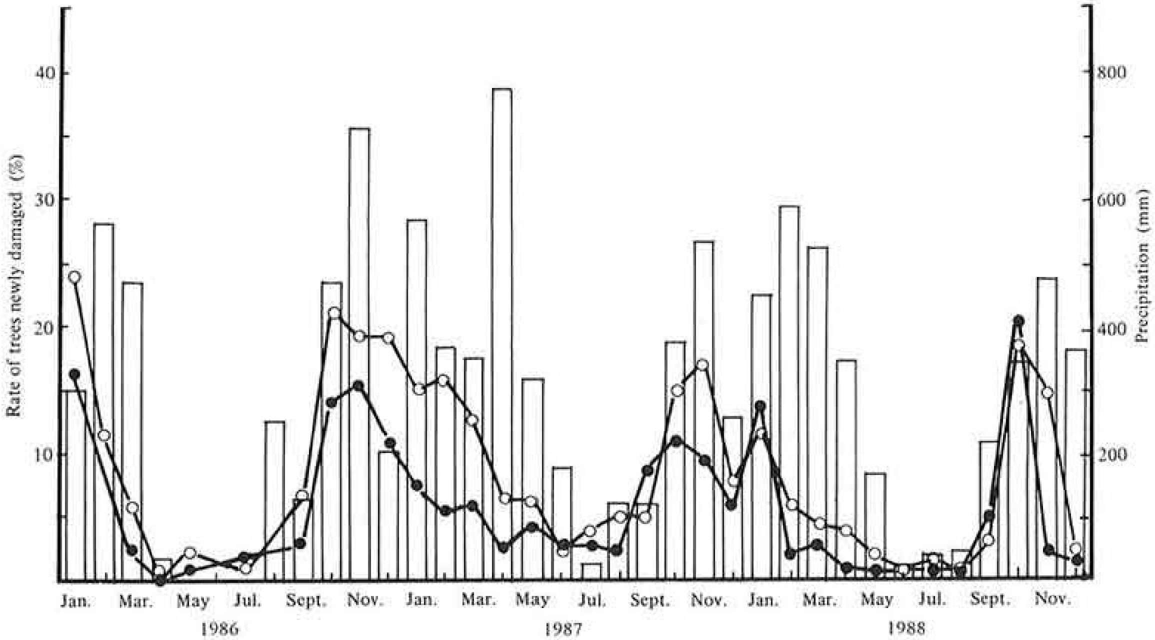

Fig. 3. Seasonal patterns of damage rates in plant number of the hosts: Cedro (○) and Caoba (●)

level decreases because of the possible high mortality of larvae and the less opportunity of mating caused by continuous and heavy rainfalls.

(3) During the dry season, the infestation level is basically maintained in low level, since oviposition sites are not sufficient enough because of limited rainfall.

Recommendation

Various approaches have been proposed in the past to solve the problems relating to *Hypsipyla*. They include biological control by parasites and microbes, chemical control using insecticides, bio-chemical control by manipulating adult moth behaviors, sterile male method, and silvicultural method[3,11]. The above result of the present study suggests that plantation under the canopy with an adequate aftercare possibly be effective for Meliaceae species to grow without heavy attacks by *Hypsipyla grandella*.

The authors express hearty thanks to Mrs. Sonia, S. T., Mr. Koike, H. and Mr. Iizuka, K. for their cooperation, and also to Dr. Matsui, M., Dr. Kobayashi, F. and Dr. Kobayashi, K. for their guidance in implementing the present study.

References

1) Commonwealth Agricultural Bureaux (1980): Distribution maps of pests. Series A (Agriculture), Map no. 447, 448, London.
2) Dubois, J. L. C. (1971): Silvicultural research in the Amazon. National forestry school Curitiba, Brazil (FAO).
3) Gray, B. (1972): Economic tropical forest entomology. *Ann. Rev. Entomol.*, **17**, 313-354.
4) Grijpma, P. (1970): Immunity of *Toona iliata* var. *australis* and *Khaya ivorensis* to attacks of *Hypsipyla grandella* Zeller in Turrialba, Costa Rica. *Turrialba*, **20**, 85-93.
5) Grijpma, A. & Gara, R. I. (1970): Studies on the shoot borer *Hypsipyla grandella* Zeller. I. Host selection behavior. *Turrialba*, **20**, 233-240.
6) JICA (1979): Report on preliminary survey of the forest development cooperation in the Republic of Peru, Tokyo.
7) Kobayashi, F., Yamazaki, S. & Ikeda, T. (1986): *Hypsipyla grandella* threatening Meliaceae plantations in Peruvian Amazon. *In* Proceedings of 18th IUFRO World Congress Division II, 146-153.
8) Kokubo, J. (1979): Damage and control of the

mahogany shoot borer. *Forest Pests*, **28(7)**, 7–10 [In Japanese].
9) Matsui, M. (1986): Regeneration trial in Peruvian Amazon. *Tropical Forestry*, **6**, 14–18 [In Japanese].
10) Nickle, W. R. & Grijpma, P. (1974): Studies on the shoot-borer *Hypsipyla grandella* (Zeller) (Lep., Pyralidae). XXV. *Hexamermis albicans* Siebold (Nematoda, Mermithidae) a parasite of the larva. *Turrialba*, **24**, 222–226.
11) Sannchez, J. C., Hosten, E. H. & Whitmore, J. L. (1976): Comportamientode cinco especies de Meliaceae en turrialba, Costa Rica. Studies on the shoot borer *Hypsipyla grandella* (Zeller) Lep. Pyralidae vol. III. (ed. J. L. Whitmore), *CATIE Misc. Pub.* **1**, 97–103.
12) Yamazaki, S. (1987): Serious damage of mahogany by a shoot borer, *Hypsipyla grandella* Zeller (Lepidoptera, Pyralidae). *Tropical Forestry*, **8**, 26–34 [In Japanese].

(Received for publication, Sept. 7, 1989)