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Attack by the Mahogany Shoot Borer, *Hypsipyla grandella* ZELLER (Lepidoptera: Pyralidae), on the Meliaceous Trees in the Peruvian Amazon[1]

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The infestation of meliaceous species by the mahogany shoot borer, *Hypsipyla grandella* ZELLER, was investigated in plantation areas of the Peruvian Amazon. Damage was particularly great on line plantings and plantings in opened areas. *Cedrela odorata* was attacked by *H. grandella* from 0 to 10 times during 16 months, averaging 3 attacks per tree. The upper main stem of trees was more frequently attacked than offshoots or middle stems. First to second instar larvae were mostly found in the offshoot, whereas the older larvae were found most frequently in the upper main stem. Both *C. odorata* and *Swietenia macrophylla* sprouted 3 to 5.5 times a year, averaging 3.7 and 4.4 times, respectively. Flushing was concentrated in the rainy season and was rare in the middle of the dry season, resulting in a rapid increase of *H. grandella* in the former. The attack of *Hypsipyla* on the main stem triggered sprouting, which seemed to keep the pest density at a certain level in the dry season. The percentage of newly attacked trees per month tended to be slightly higher in *C. odorata* than in *S. macrophylla*.

Key words: *Hypsipyla grandella*, *Cedrela odorata*, *Swietenia macrophylla*, Peruvian Amazon

INTRODUCTION

Hypsipyla are micro-lepidopterous shoot borers, widely distributed in tropical and subtropical regions in the world. Among 4 species of *Hypsipyla* (*Hypsipyla grandella*, *H. ferrealis*, *H. fluviatella* and *H. dersimacula*) in the New World, *H. grandella* is most widely distributed in Central and South America, severely damaging meliaceous species. In the Old World, *Hypsipyla robusta* occupies a similar status as a pest among 6 other species, *H. albipartalis*, *H. debilis*, *H. elachistalis*, *H. ereboneura*, *H. rotudipex* and *H. swezwy* (BRADLEY, 1968).

H. grandella attacks all meliaceous trees native to Latin America, particularly *Cedrela* and *Swietenia* species (GRIJPMA, 1970). It lays eggs mainly on young leaves, and

[1] This research was part of a cooperative project, started in 1982 in Peruvian Amazon forests, conducted by the National Institute of Forestry, Peru and the Japan International Cooperation Agency.

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hatched larvae bore into and hollow out branches or stems. The main damage occurs when larvae bore into terminal shoots of young trees. The shoot breaks and vertical growth completely ceases. Resprouting, occurring more frequently in the rainy season (usually October to April in Peruvian Amazon) than in the dry season (May to September), generally results in the development of numerous lateral branches and consequently in badly formed trees. Tree height is thus reduced by repeated attacks of the insect and mortality can occur. In nature, *H. grandella* appears throughout the year. Its life cycle, from egg eclosion to adult emergence, lasts an average of 40 d under laboratory conditions (YAMAZAKI et al., unpublished).

In the Peruvian Amazon, large numbers of many useful trees including *Cedrela* and *Swietenia* have been lost for decades to migration farming and selective cutting. Consequently, a demonstrative research project for the development of afforestation technology was started in 1982 by the National Institute of Forestry and Zoology, Peru and the Japan International Cooperation Agency, Japan. The purpose is recovery and sustainable use of such valuable natural resources (MATSUI, 1986). Since then the two most useful species, *Cedrela odorata* and *Swietenia macrophylla*, have been planted in large numbers in various ways, but have been heavily attacked by *H. grandella* during the 2 years after plantings in the plantations. Since trees over 6 m high are not attacked as heavily as smaller ones (GRIJPMA and GARA, 1970), effective control measures are needed for young plantations.

The objective of this study is to show overall aspects of *H. grandella* infestation in plantation areas from the phenological point of view of the host plant-insect relationship.

MATERIALS AND METHODS

The study site was established in the Von Humboldt National Forest at 9° S latitude, approximately 80 km west of Pucallupa in the upper reaches of the Amazon in Peru. Seven hundred ha of national forest land was used for the project. Average rainfall is over 4,000 mm/y and the mean annual temperature is 25°C. Spanish cedars (*Cedrela odorata* and *C. fissilis*) and mahoganies (*Swietenia macrophylla*) that were studied had been bred in a nursery from seeds of native trees in or near the study site, and were transplanted in plantations as 80–100 cm height seedlings. In the nursery, insect attacks on seedlings were prevented by spraying insecticides (mainly fenitrothion) every 2 weeks.

Infestation level of *H. grandella* on the 3 species was studied in areas of line-planting with 5, 10 or 30 m width, of clearings, of underplanting, and of plantings in open areas and natural regeneration. Monthly censuses of the pest were made on ca. 2,000 trees of *C. odorata* and ca. 1,000 of *S. macrophylla* in all the plantation areas from 1986 to 1988. Current and past attacks by the moth on trees were easily distinguished. Current attacks were recognized by breaking of branches or shoots, or by exudation of oleoresin, whereas past attacks were indicated by a knot-like swelling made by reproduced tissues on the main stem. Infestation level was also studied in an open area (ca. 0.6 ha) containing 662 *C. odorata* with 2.5×2.5 m spacing in 1987.

Attacked parts of trees and developmental stages of attacking insects were studied in another open area, where 618 *C. odorata* (2 y old) were planted at 2×2 m spacings, from August, 1988 to March, 1989. Every tree was checked for infestation every 2 months, and attacked parts were removed with insects after recording.

Tree phenology of *C. odorata* and *S. macrophylla* was studied in 2 experimental sites

(0.3 ha and 0.2 ha), where 110 or 140 trees of each species were planted at 3×3 m spacings from 1987 to 1989. An insecticide (2% methylfenvalerate) was sprayed throughout the year to secure insect-free trees. Trees which were killed during the experimental period were eliminated from the records.

RESULTS AND DISCUSSION

Infestation levels and attack frequencies

More than half of trees in the study area showed signs of current or previous attack. The remainder were located in the natural regeneration area, one of 2 under-planted *C. odorata* areas and in 2 line-planting *S. macrophylla* areas (Table 1), but grew poorly in because of being shaded by surrounding vegetation. A census in one area showed that 98.7% of *C. odorata* trees were attacked once or more during the 16 months after

Table 1. *H. grandella* infestation on 3 meliaceous species with various plantings

Tree species	Area[a] code	No. of trees investigated	Year[b] of planting	Percentage of trees[c] with	
				current attacks	past attacks
C. odorata	LP-1 (5 m)	42	1982	12	100
	LP-2 (5 m)	73	1984	33	41
	LP-3 (5 m)	42	1984	38	50
	LP-4 (10 m)	38	1984	34	—[e]
	LP-5 (10 m)	78	1984	40	—
	LP-6 (30 m)	35	1983	34	100
	LP-7 (30 m)	169	1983	49	96
	Natural	40	1984[d]	18	18
	UP-1	19	1983	0	11
	UP-2	20	1984	95	100
	Open area	161	1983	24	96
C. fissilis	LP-1 (5 m)	19	1982	21	89
	Open area-1	47	1984	96	98
	Open area-2	20	1985	55	60
S. macropylla	LP-1 (5 m)	36	1982	8	81
	LP-2 (5 m)	73	1984	5	12
	LP-3 (5 m)	50	1984	14	18
	LP-4 (10 m)	47	1984	49	—
	LP-5 (10 m)	36	1984	28	—

The investigation was conducted in September and October 1985.

[a] LP: line planting area where trees were planted at a distance indicated by a numeral in parentheses, Natural: natural regeneration area, UP: plantings under the canopy of surrounding trees, Open area: area less than 1 ha where trees were planted at 2–2.5 m spacing.

[b] Trees were transplanted in January or February.

[c] "current" attack was recognized by breakage of branches or shoots, or exudation of oleoresin, whereas past attacks were recognized by a swollen knot made by the reproduced tissues on the main stem.

[d] Tree heights were 50–80 cm at the time of investigation.

[e] Not investigated.

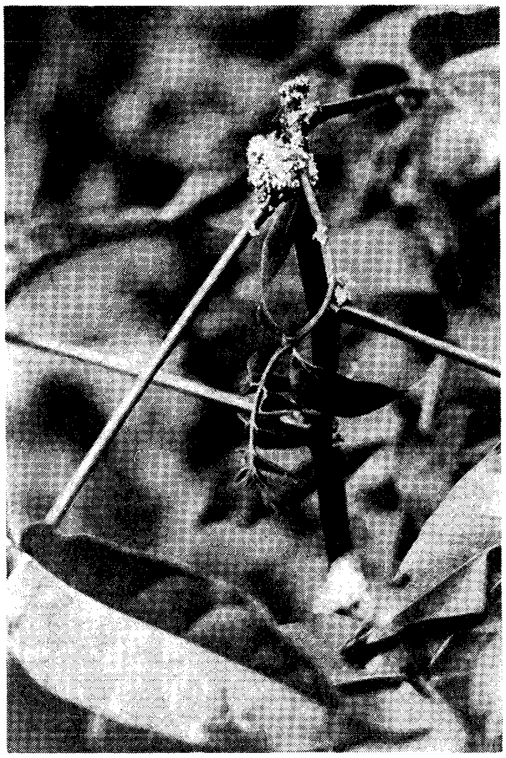

Fig. 1. Damage on a top shoot of *C. odorata*.

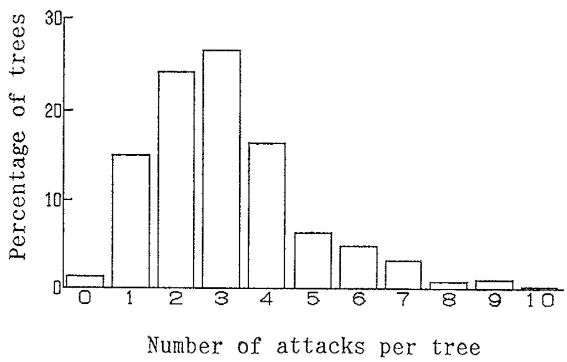

Fig. 2. Frequency distribution of the number of *H. grandella* attacks on individual *C. odorata* trees during 16 months after planting.

planting, or when they were 2 or 3 y old; the number of past attacks varied from 0 to 10, averaging 3.1 per tree (Fig. 2). Larvae that attacked young tree branches subsequently moved into the main stems because of food shortage, inducing a knot-like swelling.

Attack sites on trees and developmental stages of insects

Among a total of 2,620 *C. odorata* trees inspected 9 times during the season, 362 (13.8%) were attacked. Young larvae (1st to 2nd instar) were most frequent in the offshoot, whereas older larvae (3rd to 4th instar) were most frequent in the upper stem. The 5th or final instar larvae and pupae were also most frequent in the upper stem but were not rare in the middle or lower stem (Table 2). These observations suggest that eggs were laid either on newly developed shoots or fresh foliage and that hatched larvae fed on them, eventually reaching the main stem. Larvae hollowed out from the terminal shoot to the lower stem as they developed. As there were only a few younger instars in trees with old or absent foliage, sprouting and development of young leaves appear necessary for moth development.

The number of insects in an infested tree ranged from 1 to 4 with a mean of about 2.

Seasonal development of tree leaves

A 2-year investigation at a site showed that sprouting occurred 6 to 11 times (3 to 5.5 times a year) on both *C. odorata* and *S. macrophylla* (Table 3), with the mean being 3.7 and 4.4 sproutings per year per tree, respectively. Sprouting was concentrated in the rainy season from September to March and was very rare in the middle of the dry season from May to August. Similar results were obtained at another site (Fig. 3). Trees with new shoots or fresh foliage were most abundant in the middle of the rainy season but rare in the dry season, particularly from late May to early September in 1988. Figure 3 shows that there were 4 peaks of flushing in *C. odorata*, suggesting synchronization of flushing in the tree population. In *S. macrophylla*, however, peaks or synchronization were virtually absent.

In addition to the synchronized flushing, sprouting often occurred when trees were attacked by the moth. We stimulated this condition in a nursery by cutting the

Table 2. *H. grandella* infestation sites and developmental stages between August 1988 and March 1989

Infestation site[a]	No. of 1st to 2nd instar larvae (%)	No. of 3rd to 4th instar larvae (%)	No. of 5th instar larvae and pupae (%)
Offshoot	110 (82.1)	49 (12.2)	6 (3.4)
Upper stem	7 (5.2)	271 (67.2)	114 (63.7)
Middle stem	16 (11.9)	82 (20.3)	49 (27.4)
Lower stem	1 (0.7)	1 (0.2)	10 (5.6)
Total	134 (100)	403 (100)	179 (100)

[a] A stem was roughly divided into 3 parts (upper, middle and lower) by visual observation.

Table 3. Annual frequency of sprouting of *C. odorata* and *S. macrophylla* between January 15, 1987 and December 15, 1988

Annual frequency of sprouting	Percentage of trees[a]	
	C. odorata	*S. macrophylla*
3.0	13.3	1.5
3.5	34.0	13.4
4.0	31.3	23.1
4.5	16.0	32.1
5.0	4.7	26.9
5.5	0.7	3.0

[a] *C. odorata*: $N=138$; *S. macropylla*: $N=137$.

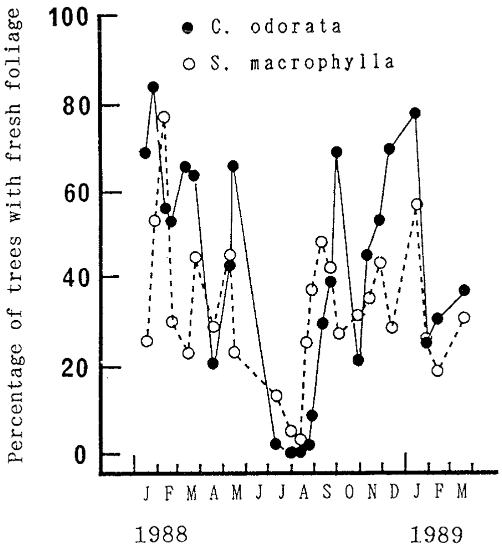

Fig. 3. Seasonal change in the percentage of trees with fresh foliage.

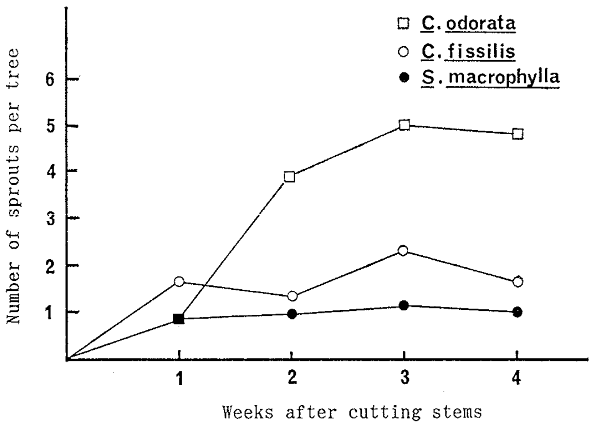

Fig. 4. Effects of stem cutting of *Mellaceae* spp. on production of new sprouts.

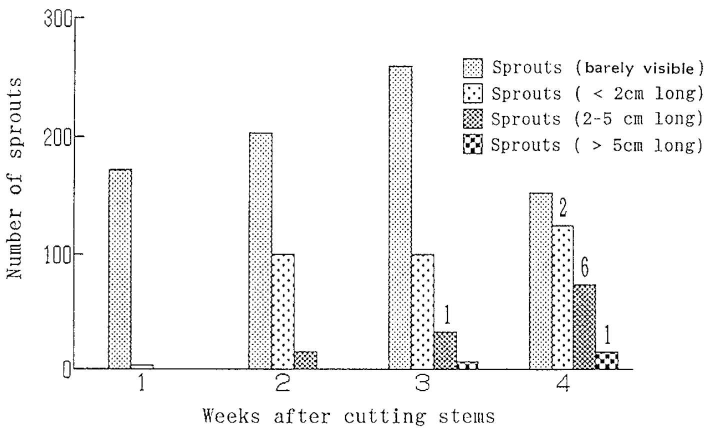

Fig. 5. Growth of *C. odorata* sprouts produced by stem cutting in a dry season. Numerals above columns show the numbers of attacks by *H. grandella*.

tips of main stems to heights of 50 to 80 cm in *C. odorata* (81 trees), *C. fissilis* (58) and *S. macrophylla* (13), in mid-July. One or 2 sprouts appeared in the 3 species within a week after cutting (Fig. 4). Further sprouting did not occur in *C. fissilis* and *S. machrophylla* but did occur in *C. odorata* in the following weeks. Attacks of *H. grandella* occurred thereafter within a month, particularly on sprouts which had developed to heights of approximately 5 cm (Fig. 5). These results suggest that the meliaceous trees, especially *C. odorata*, easily recover their growth by quick sproutings after damage by the insect. These sprouts provide the moth with an oviposition resource.

Seasonal change in fequency of attacks

Seasonal changes in the percentage of attacked trees were similar in *C. odorata* and *S. macropylla* during the 3 years, although the annual mean was a little larger in *C. odorata* (8.47%) than in *S. macrophylla* (5.82%) (Fig. 6). Attack intensity started to increase in September (the beginning of the rainy season), peaked in October, gradually decreased toward the end of the rainy season and further declined in the dry season from May to August. The increase in insect attacks was synchronous with rainfall. It seems that the rapid development of new foliage triggered by the rainfall at the beginning of the rainy season causes a rapid increase of *Hypsipyla* density, resulting in a peak attack level in October. However, it is unknown what prevents *Hypsipyia* from further increasing in spite of an additional supply of new shoots or fresh foliage throughout the rainy season.

If there was some precipitation in the dry season, new foliage development ensured larger densities of *Hypsipyla* (June to September 1987) (Fig. 6) than in years with less precipitation. When few sprouts occur in the middle of the dry season, insect attacks which trigger sproutings may play an important role in keeping the pest density at a certain level until the beginning of the rainy season. Besides, seeds of *C. odorata* and *S. machropylla* hosts and of a non-host, *Cedrelingas catenaeformis*, provide the moth with food, as more than 10% of seeds are infested with *H. grandella* larvae (Yamazaki, un-

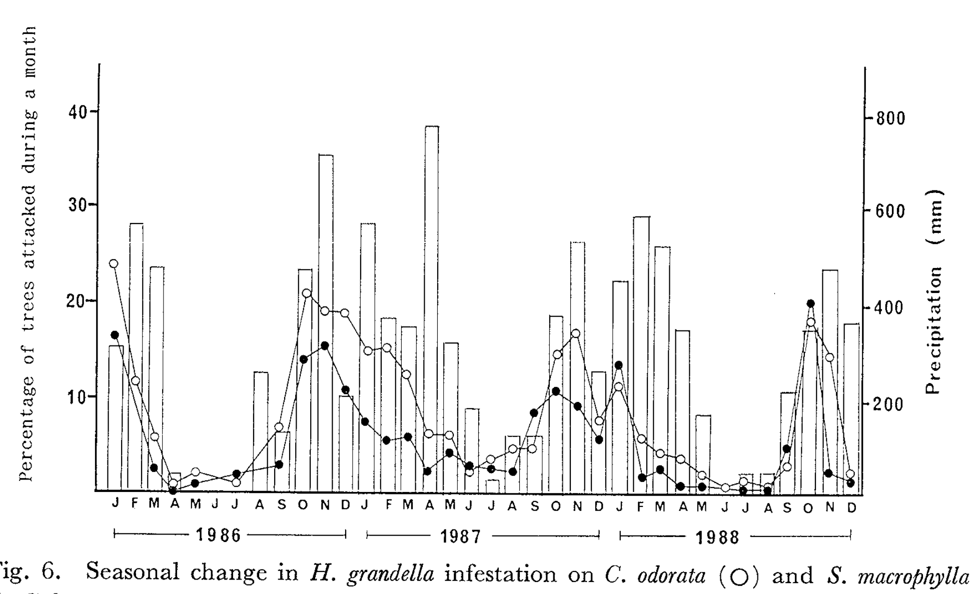

Fig. 6. Seasonal change in *H. grandella* infestation on *C. odorata* (○) and *S. macrophylla* (●). Columns represent monthly precipitation.

published). However, the extent of their contribution is unknown, because the fruiting season cycle is unstable (YOKOTA, unpublished).

Based on extensive experiments, GRIJPMA and GARA (1970) indicated that *H. grandella* selects hosts by olfactory response to volatiles emanating from fresh leaves. Our results, in which moth infestation was highly correlated with sprouting and fresh foliage, agree with this.

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