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ECONOMIC ENTOMOLOGY IN TROPICAL FOREST PLANTATIONS: AN UPDATE

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SCHABEL, H. G., HILJE, L., NAIR, K. S. S. & VARMA, R. V. 1999. Economic entomology in tropical forest plantations: an update. At a time when natural tropical forests continue to shrink, tree plantations are being expanded. The goal is to reduce pressures on remaining natural forests, to exploit the enormous yield potential of certain species, and increasingly to return degraded sites to woody cover. Pests continue to interfere with this effort. This paper was developed to provide an update on the pests and their status for the last 25 years. The major economic pest insects of tropical regions are briefly introduced, as they affect fruit, seed, as well as seedlings, and plantation trees of various ages. Pest management strategies of significance utilised to manage these insects, key literature, and some general remarks concerning geographic, food preference and other patterns are included.

Key words: Insect pests - tropical - seed - nursery - plantation

SCHABEL, H. G., HILJE, L., NAIR, K. S. S. & VARMA, R. V. 1999. Entomologi ekonomi di ladang hutan tropika: laporan terkini. Pada ketika hutan hujan tropika semula jadi terus berkurangan, ladang-ladang pula semakin banyak ditubuhkan. Tujuannya ialah untuk mengurangkan tekanan ke atas hutan semula jadi yang masih wujud, untuk mengeksploitasi potensi hasil yang menguntungkan beberapa spesies tertentu, serta terus mengembalikan kawasan tanah usang menjadi kawasan yang berkayu. Perosak pula sentiasa mengganggu usaha ini. Artikel ini disediakan untuk mengemaskinikan maklumat mengenai perosak dan statusnya bagi 25 tahun terdahulu. Serangga perosak utama yang menggugat ekonomi di kawasan tropika juga diperkenalkan secara ringkas kerana ia melibatkan buah, biji benih, anak benih dan pokok-pokok ladang pelbagai peringkat umur. Strategi pengurusan perosak berkenaan yang digunakan untuk menguruskan serangga-serangga ini, maklumat-maklumat penting dan beberapa tanda umum berhubung dengan geografi, makanan dan pola-pola lain juga disertakan.

Introduction

Natural forests in the tropics have been subject to accelerating change during the past few decades. Sharp population increases, coupled with modern technology and globalisation of markets, among other factors, have resulted in annual forest losses estimated at 17 million ha according to FAO (1990) and degradation of possibly more than twice that area. Annual rates of deforestation in percentages of forests remaining are 0.7 for Africa, 0.8 for America and 1.2 for Asia. In order to deal with these increasing human pressures on natural resources, solutions in sustainable development are being sought to reconcile human needs with the conservation of nature.

One such solution is to take pressures off natural forests by pursuing plantation options. In a number of tropical countries plantations have, because of their potentially impressive yield, played commercial roles since the colonial age, but now they may also be necessary to reclaim, rehabilitate and even restore degraded land (Evans 1992, Lieth & Lohmann1993). Reported tropical plantation area by 1990 was almost 44 million ha, three fourths of this in Asia/Pacific, almost one fifth in America, the remainder in Africa. The area under plantation continues to increase.

Previous experience with nurseries and plantations in the tropics has often revealed serious problems with pests (Gray 1972, Zobel *et al.* 1987). In the context of expanding plantations, it is of acute interest to identify trends in this conflict. For brevity, this paper intends to focus only on the more serious tropical forest insects which have, during the last 25 years, attained pest status in seeds, nurseries and plantations. We interpret tropics as that part of the world located between latitudes 23° 27' north and south of the equator. Insects considered economically most important (Table 1) were selected subjectively, based on their regional impact, evidence available in the literature, and personal familiarity of the authors and cooperators with various regions of the tropics. Only insects affecting living trees in seed, nursery, or plantation contexts were considered, and only key references are listed. Quasi-agricultural and other woody specialty crops such as bamboo, rattan, palms and rubber trees were excluded, as were pests of trees in agroforestry.

This paper is divided into three sections. The first deals with the major pests and is organised according to the part or stage of trees affected or the nature of damage. The second takes stock of current pest management methods practised in tropical forest plantations. The third concludes with general observations.

Major tropical forest pest insects

Pests of fruit and seed

Seeds of virtually all forest trees are attacked by insects, either while still on the tree, after dropping, or in storage. This may have implications for the ability of the tree to naturally regenerate, or for seed collecting and the use of seeds in gene banks,

trade, or nursery contexts. The majority of pest species reported belong to a few families of Coleoptera (Bruchidae, Curculionidae), Lepidoptera (Pyralidae, Tortricidae), and some Heteroptera. In the old world tropics in particular, bruchids routinely complicate seed storage, especially of legumes, but not any one species has warranted other than routine precautions.

Pests of seedlings and transplants

Within this category fall insects that cause one of the following types of damage: root-feeding, seedling-cutting, sap-sucking and defoliating. The majority of defoliators and sap-suckers also affect older trees on a recurrent or sporadic basis, but typically with less serious consequences.

Throughout the tropics, the main seedling root-feeders are white grubs (Col: Scarabaeidae) and in the case of exotics, especially eucalypts, various termites (Termitidae). Equally widespread and usually with little host-specificity, are certain seedling-cutters (Lep: Noctuidae, Pyralidae). None of the numerous sap-sucking Heteroptera (notably Aphidoidea, Coccoidea and Psyllidae) is of great significance, except the lacebug *Dictyla monotropidia* (Tingidae), a chronic pest of young *Cordia alliodora* in the neotropics.

A great many defoliators representing over 30 families of more or less polyphagous Lepidoptera, two families of Coleoptera (Chrysomelidae; Curculionidae), and three of Hymenoptera (Apidae; Diprionidae; Formicidae) make occasional appearances in tropical nurseries. Outstanding pests in this category, however, are only the leaf-cutting ants (especially *Atta* spp.), which are widespread in the neotropics. Their huge colonies frequently denude entire plantations of various ages and species, including nurseries.

Pests of plantations past the seedling stage

This category includes bud-shoot-feeders, gall-makers, sap-suckers, defoliators, phloem-feeders, wood-borers, and root-feeders. Their significance in young plantations usually exceeds that in older ones.

Bud and shoot-feeding

This is a particularly destructive habit of some Lepidoptera and Coleoptera throughout young plantations of the tropics, disfiguring many trees. While most bud-shoot-feeders destroy shoots from within, certain Hemiptera are external shoot-wilters, which do not attain the significance of the former. Most bud-shoot damage is of concern in precious hardwoods, but pines in Central America and Asia also suffer serious damage from shoot-borers. In Asia, *Dioryctria* spp. (Lep: Pyralidae) are the most notable, although not on the same scale as *Rhyacionia frustrana* (Lep: Tortricidae) whose economic impact is being felt in pines from Nicaragua to Canada. Bud-shoot-feeding is particularly prevalent in humid forests of West Africa, as reflected in the fact that almost half of the insects listed as serious

for this continent (Table 1), are included in this category. They belong to three families of Lepidoptera, and two of Coleoptera. One of them, *Hypsipyla robusta* (Lep: Pyralidae), also causes damage in East Africa and in most of the Asia-Pacific region, where only Fiji is spared. Together with its equally widespread (Florida to Argentina) neotropical kin, *H. grandella*, these shoot-borers consistently frustrate attempts to culture mahoganies (Meliaceae), indigenous and exotic (Figure1). The high value of these trees, and the pantropical distribution and very low action threshold for this pest, where one larva suffices to cause irreparable disfigurement, make this one of the most vexing insect pest problems of the tropics.

Figure 1. Forked stems in American mahogany (*Swietenia macrophylla*) as a result of hyphenate shoot-boring *Hypsipyla grandella* (Lep: Pyralidae). This insect genus represents the most serious pest problem of meliaceous mahoganies almost throughout the tropics, defying consistently effective control (Photo: F. Solano).

Table 1. The most important economic pest insects in tropical forest plantations

Species (Alphab.)	Order/Family	Region ✤	Main host(s)	Type of damage*
AFRICA				
Analeptes trifasciata	Col:Cerambycidae	W	Bombacaceae; *Eucalyptus*	bs
Anaphe venata	Lep:Notodontidae	W	*Triplochiton scleroxylon*	d
Apate spp.	Col:Bostrichidae	W	*Terminalia ivorensis* (polyph.)	bs
Cinara cupressi	Het:Aphididae	E	*Cupressus; Juniperus procera; Widdringtonia nodiflora*	s
Godasa sidae	Lep:Arctiidae	W	*Mansonia altissima; Cedrela odorata* (polyph.)	d
Hypsipyla robusta	Lep:Pyralidae	W & E	Meliaceae	bs (fs,p)
Lamprosema lateritialis	Lep:Pyralidae	W & Ce	*Afrormosia; Pericopsis elata*	d
Orygophora mediofoveata	Lep:Noctuidae	W	*Nauclea diderichii*	bs
Phoracantha spp.	Col:Cerambycidae	S	*Eucalyptus* spp.	w
Phytolyma (lata) spp.	Het:Psyllidae	W & E	*Chlorophora* (=Milicia)	g
Plagiotriptus spp.	Orth: Eumastacidae	E	*Pinus* (polyph.)	d
Termites (several spp.)	Iso: Termitidae	All	*Eucalyptus* spp.	r (w)
Tridesmodes ramiculata	Lep:Thyrididae	W	*Terminalia*	bs(w)
AMERICA				
Apate monachus	Col:Bostrichidae	Ce&Ca	Many	w
Atta spp.	Hym:Formicidae	All	Many	d
Cryptotermes brevis	Iso:Kalotermitidae	All	Many	w
Dendroctonus frontalis	Col:Scolytidae	Ce&N	*Pinus* spp.	p
Dictyla monotropidia	Het:Tingidae	All	*Cordia alliodora*	s
Hypsipyla grandella	Lep:Pyralidae	All	Meliaceae	bs (fs,p)
Phoracantha semipunctata	Col:Cerambycidae	S	*Eucalyptus* spp.	w
Platypus spp.	Col:Platypodidae	All	Several	w (p)
Rhyacionia frustrana	Lep:Tortricidae	Ce&N	*Pinus* spp.	bs
Steirastoma histrionica	Col:Cerambycidae	Ce	*Bombacopsis quinatum*	w
Xyleborus ferrugineus	Col:Scolytidae	All	Many	w (p)
ASIA-PACIFIC				
Aristobia horridula	Col:Cerambycidae	Thailand, India	*Pterocarpus macrocarpus*	w
Calopepla leayana	Col:Chysomelidae	S&SE	*Gmelina*	d
Dioryctria spp.	Lep:Pyralidae	S&SE	*Pinus* spp.	bs
Eutectona machaeralis	Lep:Pyralidae	S&SE	*Tectona*	d
Hoplocerambyx spinicornis	Col:Cerambycidae	India	*Shorea robusta*	w
Hyblaea puera	Lep:Hyblaeidae	S&SE	*Tectona*	d
Hypsipyla robusta	Lep:Pyralidae	Asia (exc. Fiji)	Meliaceae *(Swietenia)*	bs(fs,p)
Ozola minor	Lep:Geometridae	Philippines	*Gmelina*	d
Shizocera sp.	Hym:Argidae	Vietnam	*Manglietia glauca*	d
Termites (several spp.)	Iso:Termitidae	All	*Eucalyptus* spp., conifers	r(p,w)
Tingis beesoni	Het:Tingidae	SE	*Gmelina*	s
Xyleutes ceramica	Lep:Cossidae	SE	*Tectona; Gmelina*	w
Xystocera festiva	Col:Cerambycidae	SE	*Paraserianthes falcataria*	w

✤ Ca=Caribbean, Ce=Central, E=East, N=North, SE=Southeast, S=South, W=West.
* Damage: bs=bud-shoot-feeder, d=defoliator, fs=fruit-seed-feeder, g=gall-maker, p=phloem-feeder, r=root-feeder, s=sap-sucker, w=wood-borer.

Gall-makers

Certain insects causing various hypertrophies, pose similar, if not quite as widespread problems. This is certainly true for *Phytolyma* spp. (Het: Psyllidae), which are to African teak [*Chlorophora* (=Milicia)] what *Hypsipyla* spp. are to mahoganies. Galls of this insect severely disfigure not only shoots, but also buds and foliage of young trees, often killing them. The Americas as well as Asia/Pacific have been spared serious problems with gall insects. Only minor damage is caused to teak in India and *Alstonia* in Bangladesh.

Sap-suckers

Although represented in great diversity in the tropics, only few Heteroptera have to date been in the alarm category. One of them, *Heteropsylla cubana* (Het: Psyllidae), recently swept the Asia-Pacific and Africa in a matter of years, but since its host *Leucaena* spp. is not a timber species, this insect does not warrant more attention here. A similarly rapid, if not quite as extensive spread, was observed with *Cinara cupressi* (Het: Aphididae), a native of the northern hemisphere, which first surfaced in Malawi in 1986, and within a few years had spread to at least eight neighbouring countries. This insect is a serious threat to Cupressaceae. Within three years of its appearance in Malawi, 15 % of this country's cypress trees had died from attacks by this insect, and since 1990 over half of Kenya's cypress plantations have suffered severe damage and mortality. *Cinara cupressi* is the fourth species of conifer aphid to have been introduced into Africa. The others infest pines in various highlands, but are not quite as aggressive as the cypress aphid, which under African conditions reproduces parthenogenetically the year round. Young plantations of *Gmelina* in Asia are often seriously damaged by *Tingis beesoni* (Het: Tingidae).

Defoliators

Like sap-suckers, many tropical defoliators are rarely specific to certain age classes of hosts. In the neotropics, even though numerous Coleoptera (Chrysomelidae and Curculionidae) and more than 270 species of lepidopterous defoliators (esp. Arctiidae, Geometridae, Noctuidae and Saturniidae) have been reported from various trees, only a few stand out. These include *Thyrinteina arnobia* (Geometridae), *Eupseudosoma involuta* (Arctiidae) and *Sarsina violascens* (Lymantriidae), which attack eucalypts. However, none of these attains the significance of leaf-cutting ants in that region. In West Africa, on the other hand, several Lepidoptera, including *Godasa sidae* (Arctiidea) and *Lamprosema lateritialis* (Pyralidae), are listed as important defoliators of various precious hardwoods (Table 1), although *Anaphe venata* (Lep:Notodontidae), which commonly defoliates older natural stands of *Triplochiton scleroxylon* in Ghana, is expected to become a major plantation pest there once young plantations of this species reach more

advanced age. In East Africa, at least 63 species of lepidopterous defoliators have been reported from various species of pine and cypress, none of them outstanding. *Plagiotriptus* spp. grasshoppers (Eumastacidae), however, have become persistently severe defoliators of pines (Figure 2) in parts of East Africa. In Asia, almost half of insects listed as economically serious, are defoliators associated with teak, *Gmelina, Manglietia* and other hardwoods. Most of these are Lepidoptera, while one is a leafbeetle (Chrysomelidae), and one a sawfly (Hym:Argidae). Caterpillars of *Hyblaea puera* (Hyblaeidae) and *Eutectona machaeralis* (Pyralidae) have been notorious pests of teak plantations of any age in Asia.

Figure 2. Pair (note much smaller male) of *Plagiotriptus* sp. (Orth: Eumastacidae) on *Pinus patula*, Morogoro, Tanzania (Mag.2x). First observed in Malawi in 1965, this is one of the many indigenous tropical hardwood defoliators, which are now serious pests in exotic conifers. (Photo: H. G. Schabel).

Bark- and wood-borers

The most notable phloem-feeders in the tropics are Scolytidae. Only one species though, *Dendroctonus frontalis*, rivals the impact of bark beetles as documented for temperate zones. This particular beetle has enormous reproductive potential, and causes huge epidemics in both natural and planted pine from the southeastern United States to Nicaragua. Some other scolytids (*Xyleborus* spp.) and platypodids (*Platypus* spp.) are notable as wood-boring ambrosia beetles, which vector symbiotic fungi that cause vascular wilts or wood stain. *Xyleborus ferrugineus*, which is an important cacao pest in the neotropics, also attacks many forest tree species, including mahogany, *Cedrela odorata* and *Bombacopsis quinatum*. *Gmelina* and eucalypts are affected by *P. parallelus* and *P. sulcatus* respectively. Many other scolytids and platypodids are polyphagous pests of declining, or recently dead trees only.

Other important coleopterous wood-borers in plantations are primarily Cerambycidae. These include *Hoplocerambyx spinicornis* in *Shorea robusta*, *Xystocera festiva* in *Paraserianthes falcataria* and *Aristobia horridula* in *Pterocarpus macrocarpus*, all in Southeast Asia, while *Steirastoma histrionica* in *Bombacopsis quinatum* ranks prominent in Central America. *Phoracantha* spp., cerambycids from Australia, are now well entrenched in eucalypt plantations in parts of tropical Africa and South America. Few other beetles (Bostrichidae, Buprestidae), as well as hymenopterous (Apidae), and dipterous wood-borers (Pantophthalmidae), although common, have attained serious status in any region. However, at least one lepidopterous wood-borer, *Xyleutes ceramica* (Cossidae), known as the bee hole borer, is a serious pest of teak plantations in Thailand, Myanmar and Indonesia. Although trees are not killed, repeated attacks of this insect riddle the wood with numerous holes. In northern Thailand often more than 80 % of plantation trees are affected. An ecological equivalent, *Alcterogystia cadambae*, causes similar damage in southern India. Various species of *Neotermes* (Kalotermitidae) have recently caused damage by feeding on the trunks of live mahoganies in Fiji, while many other termites are serious throughout the Old World Tropics.

As a footnote, no serious, if any, root-feeders have to date been implicated as pests of maturing trees in tropical plantations.

Pest management approaches

Generally no control measures are practised against tropical forest fruit and seed insects, other than timely collection, rapid use of recalcitrant seeds, and proper storage of orthodox ones.

Only subterranean termites attacking eucalypt seedlings call for routine prophylactic applications with insecticides (Cowie *et al.* 1989), while other nursery insects are usually dealt with in remedial fashion only after reaching high densities (Sutherland & Glover 1991). White grubs are treated with insecticides such as carbaryl, malathion and trichlorophon, which replaced the previously common chlorinated hydrocarbons. Among the newer products, carbaryl, because of its effectiveness and ease of use, is the most widely accepted. In India, chlorpyriphos,

another pesticide with low persistence, has been standardised for termite control on potted eucalypt seedlings prior to planting (Varma & Nair 1996).

Other than white grubs and termites, both subterranean, occasional outbreaks of beetle or caterpillar defoliators, are dealt with by handpicking. While this is usually adequate, applications of botanicals (esp. neem extracts) and insecticidal soaps, the latter against sap-suckers, are increasingly practical (Sutherland & Glover 1991). Because pure diesel oil proved only partially successful against leaf-cutter ants, bait laced with myrmex is the currently most effective way of dealing with these insects (Cherret & Peregrine 1976, Zobel *et al.* 1987). Various crop residues, such as orange, pineapple, eucalyptus leaves and peanut shells serve as bait. An unfortunate result from the elimination of ant colonies is the subsequent accelerated rate of recolonisation with these pests.

Pesticides, while more the rule than the exception in nurseries, are for economic, ecological and environmental reasons less feasible in the field. However, privately held teak estates in India have opted for this solution and pest emergencies in other particularly valuable stands may occasionally prompt this approach. High value crops, such as the mahoganies and *Chlorophora*, continue to defy plantation culture in most parts of the tropics because of persistent problems with *Hypsipyla* shoot-borers and *Phytolyma* gall insects respectively. Insecticidal solutions have of course been tried, but certain organophosphate systemics proved only partially successful, and otherwise no consistently effective methods are operational against these insects (Wagner *et al.* 1991, Newton *et al.* 1993). For lack of solutions, these tree species are still widely avoided, but interest in their culture suggests continued efforts to develop alternatives. Although promising, their mixed culture and shading of seedlings during the most vulnerable early years, is rarely practised.

Most other cultural measures attempt to bolster tree vigour. These include careful site selection, thinning, and rotation reduction. Together with sanitation, they are considered essential in dealing with *Rhyacionia frustrana* and *Dendroctonus frontalis* in tropical pines in America (Cibrian *et al.* 1995), as well as wood-borers such as ambrosia and *Phoracantha* beetles which are most destructive in stressed hosts. In Ghana, the use of prescribed burning reportedly gives good control of *Analeptes* girdlers in *Bombax* (Wagner *et al.* 1991). Trap logs are reported to be effective against the sal borer *H. spinicornis* (Roonwal 1978), but their use proved inconclusive against *Phoracantha* borers in Zambia (Ivory 1977). At this time, the use of resistant tree species and development of resistant varieties seems to offer the only long-term solution against pests such as *Chlorophora* gall insects, *Hypsipyla* borers, the cypress aphid and termites (Cowie *et al.* 1989, Ciesla 1991,Wagner *et al.* 1991, Newton *et al.* 1993).

Quarantine, even if formally in place (Odera & Arap Sang 1980), has obviously not prevented the arrival of new exotic pests such as the cypress aphid into East Africa. Besides chemical, cultural and physical and regulatory controls, biocontrol of plantation pests has been attempted, although only on a limited scale. Under tropical conditions, the temporary introduction of natural enemies in an inundative approach, seems less feasible than attempts to establish them permanently. This

has proven to be the case, e.g. with the introduction of exotic entomophages against various exotic Heteroptera (Allard & Kairo 1995). The use of entomopathogens is comparatively new in the tropics. Formulations of *Bacillus thuringiensis* have been tested successfully against the teak defoliator *H. puera* in Thailand (Chaigloum 1990) and in India standardisation of a baculovirus against the same insect is approaching the operational level (Nair *et al.* 1997).

Concluding remarks

This section offers some general remarks concerning continental differences, as well as certain geographic, food preference and pest management patterns and trends concerning the most important contemporary forest pest insects in the tropics.

Since Gray's 1972 review of economic tropical forest entomology, there has been a surge of interest in tropical forests, primarily with respect to their role in biodiversity and global climate. At the same time, concern for plantation health did not receive nearly the same attention, probably because it is less an international and more of an internal matter. This relative lack of concern is troubling in light of the fact that plantation area in the tropics increased over six fold in a matter of 25 years, and planting in the 1980s was double that of the previous decade (Evans 1992). During the same time, the number of tropical forest entomologists, increased to only 121 from about 50 (Skilling & Batzer 1995).

The bigger challenge confronted by contemporary entomologists often continues to be compounded by the same infrastructural, budgetary, educational and other impediments already listed by Gray (1972). Among continents, this may be particularly true for Africa. Of the world's 48 officially designated least developed countries (LDCs), 45 are tropical, and 34 are concentrated on this continent. Despite some centres of activity, most of Africa is severely underserved, not only in terms of entomologists, but also in plantation expansion. Literature from this continent continues to be limited, difficult to locate, and discontinuous (very little in the 1970s). On the other hand, the more progressive economies of tropical America and of Asia, while not entirely free from problems, have yielded more consistent and better documented output. Asia is recognised for its long and distinguished plantation history, and corresponding research and management experience. Tropical America, however, the forest richest and least populous tropical region, is a relative late, but dynamic newcomer to plantation forestry. During the last two decades, the increasing emphasis on plantations here has been paralleled by concurrent interest in pest insects, as reflected in a flurry of relevant literature for various regions (Gara & Onore 1989, Hilje *et al.* 1992, Hochmut & Manso 1992, Pedrosa-Macedo 1993, Zanuncio 1993, Arguedas 1997). As in other parts of the tropics, however, most forest insect research remains descriptive and prescriptive.

In assessing the most important pest insects in the tropics (Table 1), some of the same species and all of the orders recognised by Gray (1972) are included. Notably, about three fourths of the insects listed now are Coleoptera and Lepidoptera. One

beetle family (Cerambycidae) is represented well across the tropics, while in terms of economic impact, Scolytidae/Platypodidae and Formicidae are essentially American pests. The notoriety of the latter in America is matched by various termites in the Old World tropics. Among the Lepidoptera, the Pyralidae are standouts, both in number of species and in impact, America claiming one, Africa two, and Asia/Pacific three of them. Only one genus of insect, *Hypsipyla*, attains serious pest status on all three continents, while *Phoracantha* and *Apate* spp. concern two. About one third of the pest species listed primarily affect teak, eucalypts and pines, which account for almost 85 % of tropical forest plantations (Evans 1992). Others have apparently attained new pest status. As a matter of fact, about two thirds of pest species listed in Table 1 were not mentioned or classified as serious pests by Gray (1972). This discrepancy may be due to the fact that West Africa and Latin America have started or expanded plantation acreage in recent times, that new plantation species are being tried, that pest monitoring has improved, or that exotic pests have appeared. The latter are a surprisingly small group, however, only the cypress aphid and *Phoracantha* borers being of major concern. Both are restricted to exotic tree species. Still other insects, apparently are no longer economically serious, such as *Oemida gahani* (Col: Cerambycidae) and *Pineus pini* (Het:Aphididae), formerly serious pests in conifers in East Africa. On the other hand, several indigenous insects, e.g. *Analeptes* (Col:Cerambycidae), *Atta* (Hym: Formicidae), *Godasa* (Lep:Arctiidae) and *Plagiotriptus* (Orth: Eumastacidae), among many lesser ones, have broadened their food range to include exotic trees, sometimes preferentially. Thus, based on host relationships several distinctive groups emerge, namely indigenous insects affecting indigenous hosts only, indigenous pest species adopting exotics, and exotic pests affecting exotic hosts.

Insect pest management trends in the tropics indicate routine reliance on synthetic pesticides in nurseries, occasionally in plantations. However, a transition from hard to soft, i.e. less toxic, less persistent insecticides, has taken place, not eliminating, however, misuse (Wood & Pearce 1991). Many users seem to view pesticides as modern, i.e. progressive, and if affordable, are lured by their general efficiency and easy use. In the process, physical techniques (trap trees; handpicking) or botanical pesticides, which have already attained a degree of reliance in agriculture (Prakash & Rao 1997) and which could be produced locally, are often neglected. Equally promising, biological controls are only slowly gaining the attention they deserve. The literature may be replete with reference to natural enemies, but no landmark example in biological control pertains to tropical forest trees (Caltagirone 1981). Conditions which favour greater use of biocontrols, i.e. intensive research, long-term planning and monitoring, involve orchestration with international cooperators such as the International Institute of Biological Control (IIBC). These agencies have been intensifying their efforts (Allard *et al.* 1995), but much work remains to be done. Encouraging is the spearheading use of bacterial and viral formulations in several Asian countries. Unfortunately, fungal pathogens, for which tropical forest conditions seem particularly favourable, have hardly gone beyond some intitial research. The same is true for biorational methods, which are only being explored seriously in relation to wood-destroying termites.

On account of the extraordinary complexities inherent in dealing with tropical forest pests, integrated pest management in forestry, despite its promise, is generally more suggested than practised.

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