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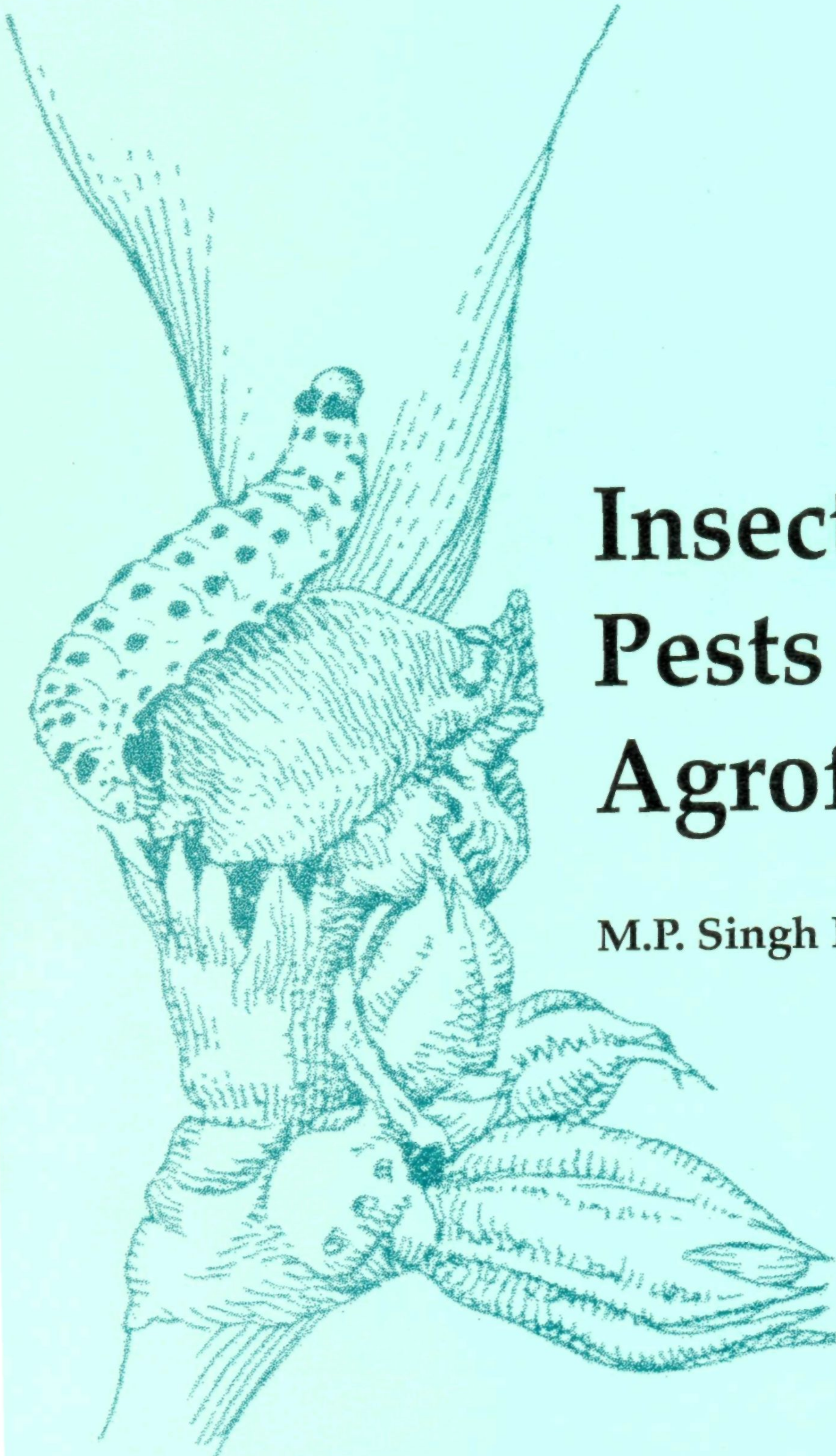

Insect Pests in Agroforestry

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Abstract

Insect-pest regulation in agroforestry is a function of interactions among the components of the system. The interactions are more intricate in complex agroforestry systems than in simple ones. Diversity of plant material in polycultural systems often leads to lower pest intensities. Taxonomically related plant species have a tendency to share common pests. The host range of phytophagous insects has a bearing on the extent of infestation on different plants in the assemblage. Polyphagous pests inflict greater injury to plants in a mixed vegetation system compared with monophagous insect pests. Changes in microclimate in a land unit on which trees and crops are co-cultivated influence insect activity within the system. The modified configuration of a field resulting from integration of trees with crops, or vice versa, may affect colonization of the plants by insect pests. The masking effect of odours released by different plant species in polycultural systems such as those of agroforestry interfere with insects' orientation abilities. Trees raised with crops in agroforestry fields act as physical barriers to the movement of insects to, from and within the field. A barrier effect can also result from the presence of non-host plants among the host plants. Agroforestry practices favour the establishment of natural enemies of insect pests. Caution is recommended when introducing exotic plants into agroforestry systems.

Little information is available about insect pests in different agroforestry systems. The effect of interactions among components on the insect pests needs to be studied. The insect-pest situation in agroforestry is reviewed. Insects associated with selected multipurpose trees and shrubs (MPTS) are listed. Studies on insect pests in ongoing agroforestry trials in Africa are discussed and future directions for research suggested.

Key words:

Insect pests, pest management, agroforestry, biological control, diversity, taxonomic alliance, host range, configuration, microclimate, masking effect, barrier, exotic plants, tree-crop competition, interaction, multipurpose trees and shrubs

1 Introduction

As primary producers, plants are a source of food for a large number of animals. Insects are a predominant group of herbivores and they have developed a variety of associations with plants over millions of years of co-evolution. The spectrum of insects associated with a plant species in one locality may be quite different from that in another place. Only a few of the many insect species associated with plants cause damage on an economic scale and are therefore considered pests.

The output of a production system can be enhanced either by an increase in production level or by a reduction in the losses from it. In agroforestry systems, attempts to increase production without heavy inputs can affect the sustainability of the systems. The potential increase in output is the difference between the current level of production and the capacity of the system. Prevention of loss will lead to a higher output from an agroforestry system without affecting its sustainability.

Insect pests are the most important group of organisms causing injury to plants in agroforestry systems. Therefore, the management of insect pests in these systems is crucial to sustained production, and even farmers have recognized this as a priority issue for agroforestry research (Prinsley 1991). Pest management figures prominently in ICRAF's strategy for research in the nineties (ICRAF 1990).

ICRAF recognized the need, as a first step, to collate information on the current status of research on insect pests in agroforestry through a literature review and field observations before any major research on insect-pest management could begin. Consequently, ICRAF constituted a one-year fellowship with assistance from GTZ to undertake the task. The objectives were (1) to review current knowledge on how mixed plant and tree communities affect insect pests and the pest-parasite complex, (2) to identify insect pests occurring in the on-going experiments in ICRAF's Agroforestry Research Networks for Africa (AFRENAs), and (3) to suggest future lines of research in the field of insect-pest management in agroforestry. However, because of the limitation of time and funds the second objective could not be accomplished satisfactorily. Only a few sites were visited and those visits, too, only once, which is not enough to identify all potential pests and establish their relative importance.

1.1 Sources of information

The literature search was carried out utilizing the library resources and documentation centres at the International Centre for Research in Agroforestry, the International Centre for Insect Physiology and Ecology, and the Kenya Forestry Research Institute. The resource materials included periodicals (journals, newsletters, magazines), books, conference proceedings, booklets, working papers, tour reports and technical reports. The principal sources of information were electronic databases. The bulk of the information was drawn from the three volumes of CABI Abstracts (vol. 1, 2, 3: 1984-1990). Other databases scanned were AGRICOLA (1970 to October 1991) and AGRIS (1986 to April 1991). The review articles and other publications listed were also made use of but without checking the primary sources.

To complement the literature review, a questionnaire was designed and dispatched to about 40 agroforestry researchers asking for information about insect pests in the systems with which they work. It was also sent to 30 different national and international organizations and networks in Africa, Asia and Latin America. The response to the questionnaire was poor, probably because there have been few experiments conducted on the entomological factors in agroforestry trials. Visits were made to the AFRENA experimental sites: Maseno in Kenya; Mashitshi and Karuzi in Burundi; Butare, Gakuta, Rubona and Rwerere in Rwanda; and Minkomeyos and Abondo in Cameroon. During these visits observations were mainly focused on the insects associated with multipurpose trees and shrubs (MPTS) as some information on insect pests of crops is already available. Frequent visits were made to the ICRAF field station at Machakos in Kenya.

2 The insect-pest situation in agroforestry

The science of agroforestry is of recent origin, although the practice is age old. There are numerous types of agroforestry system in different parts of the world. There have been few studies of insect pests in agroforestry context, although insect pests of crops that are components of agroforestry systems have been studied. Scanty information is available about the insects associated with the multipurpose trees and shrubs that are gaining greater economic importance as components of agroforestry systems. In any particular location, the insect fauna occurring on certain plant species is more or less the same, whether that plant species is in monoculture or in a polycultural assemblage such as an agroforestry system. However, the activities of these insects are not likely to be identical in any two situations. There are several factors that influence the activities of insects in agroforestry.

The mechanisms governing the insect-pest situation in agroforestry systems are yet to be investigated fully, and there have been no studies comparing the insect-pest situation in monoculture or block plantation and in agroforestry combinations. Most publications that mention pests of agroforestry either contain information on the insect pests of one component (Verma 1986, 1988; Sagwal 1987; Sen-Sharma 1987; Singh and Singh 1987; Khan et al. 1988) or underline the need for research in this field (Epila 1986; Huxley and Greenland 1989). The management of insect pests through agroforestry field design has been the subject of discussion in a few publications (Altieri et al. 1987; Epila 1988; Gold et al. 1989). Liping (1991) suggested directions for research on biological control of pests and diseases in agroforestry systems.

There have been several studies on insect activities in windbreaks, shelterbelts and hedges under temperate conditions, but these were not in an agroforestry context as most of them were restricted to woody plants. Insect dynamics in windbreaks have been investigated by Lewis (1965a, b, 1966a, b), Lewis and Stephenson (1966), Lewis (1967,1970) Lewis and Dibley (1970), Smith and Lewis (1972), Solomon (1981), Dix and Leatherman (1988), Norton (1988) and Pasek (1988) among others. The activities of insects in shelterbelt plantations have also been subject of study (Galecka and Zeleny 1969; Gorny 1970; Kyrilenko and Pysariev 1976; Slosser and Boring 1980), and there have been a few studies on hedges (Lewis 1969b, c; Hawkes 1973; Bowden and Dean 1977).

The insect pests of an agroforestry system are essentially the pests of its components: the crops and woody perennials. The dynamics of insect pests and their natural enemies are be governed by the complexity and composition of the agroforestry system. The pest situation in these systems will be influenced by the degree of interaction between the components, the type of agroforestry system and the composition of the plant communities in each component.

Interactions among the components of the agroforestry system can be either positive, negative or neutral. They are regarded as negative when pest problems are increased in an agroforestry system when compared with a monoculture block plantation. A reduction in pest activity under agroforestry indicates a positive interaction, while no change in pest intensities between monoculture and agroforestry denotes a neutral interaction from the insect-pest management point of view. Many factors govern insect-pest intensity in agroforestry and each factor may have a different effect on pests at different times and under different situations. The net outcome will be the sum of favourable and unfavourable effects on pests and their natural enemies. Some of the factors that govern the pest situation in agroforestry are described below.

2.1 Vegetational diversity

Uniformity in plant genetic material has been recognized as one of the main causes of an increase in pest problems in monoculture fields. A large number of experiments carried out under different conditions indicated a reduction in pest activity with diverse vegetation as compared with monoculture.

There are several reviews of insect abundance in diversified vegetation (Southwood and Way 1970; van Emden and Williams 1974; Goodman 1975; Cromartie 1981; Altieri and Letourneau 1982, 1984; Pimm 1984; Altieri and Liebman 1986). Studies on the effect of multiple cropping patterns have been carried out by Marcovitch (1935), Dempster and Coaker (1974), Litsinger and Moody (1976), Perrin (1977), van Emden (1977), Altieri et al. (1978), Kroh and Beaver (1978), Risch (1979), Altieri (1980) and Altieri et al. (1990). There have also been some trials with perennial orchard plants (Peterson 1926; Peppers and Driggers 1934; O'Conner 1950; Chumakova 1960; Leius 1967; Syme 1975; Dickler 1978; Altieri and Schmidt 1985; Altieri 1986).

Weeds in crop fields may affect the activity of insects on the crops. A number of experiments have been carried out to assess this effect (Pimentel 1961; Dempster 1969; Tahvanainen and Root 1972; Root 1973; Smith 1976a, b; Speight and Lawton 1976; Altieri et al. 1977; Altieri and Whitcomb 1979; Theunissen and den Ouden 1980; Altieri and Todd 1981; Altieri, Todd et al. 1981; Horn 1981; Gliessman and Altieri 1982; Altieri and Gliessman 1983; Ahmed et al. 1988).

Various workers have attempted to elucidate the ecological mechanisms underlying differences in the dynamics of insect herbivores and their natural enemies in simple and diverse crop habitats (Tahvanainen and Root 1972; Root 1973; Bach 1980a, b; Risch 1980,1981; Altieri and Letourneau 1982; Altieri and Gliessman 1983; Kareiva 1983). To explain the general reduction of pest densities in diverse plant combinations, Root (1973) proposed two hypotheses, the resource-concentration hypothesis and the enemies hypothesis. The resource-concentration hypothesis suggests that in monoculture fields where the same plant species is cultivated over large areas the herbivores find a concentrated source of food in one place that supports uninterrupted population build up. The food plants in pure stands are easily detected and colonized. The pests, particularly the specialists, exhibit longer tenure periods and higher feeding and reproductive success.

Agroforestry introduces plant diversity in a land unit, over both time and space. Complex agroforestry systems may be close to though not equivalent to natural plant communities in a stable ecosystem or a system in ecological succession. In the latter, the type and pattern of vegetation is governed by the forces of nature. The plant communities developing through natural selection have a degree of in-built resistance to insect attack. In agroforestry, however, the choice of vegetation is determined by people and depends on the objective of the system being practised. This freedom to introduce selective diversity enables agroforesters to choose plants with the desired attributes for accomplishing their objectives.

Different degrees of insect injury occur when a host plant is raised with different companion plants. A reduction in pest numbers and increase in predators was observed when blackgram *(Vigna mungo)* was intercropped with sorghum or pigeonpea, while intercropping with greengram *(Vigna radiata)* provided favourable conditions for an increase in pest numbers (Dhuri et al. 1986). The mite populations on cassava were higher in a eucalyptus-cassava combination than in a banana-cassava combination in experiments conducted by Ghosh et al. (1986). The grasshopper populations in fields of pearlmillet and sorghum with interspersed neem trees were lower than those in fields with *Acacia arabica* (Amatobi et al. 1988). Six years after eucalyptus trees were introduced in Malnad, India, a survey revealed that the number of insect species was reduced to a quarter compared with that in areas where no eucalyptus were present (Chakravarthy et al. 1986). Interplanting beans or allowing weeds to grow with collards considerably decreased flea beetle densities on the collards and minimized leaf damage (Altieri et al. 1990).

Insect population dynamics are greatly influenced by the type of vegetation in any plant assemblage. Generally, pest levels are not reduced to the same degree in polyculture systems (Risch et al. 1983). Polyphagous pests exhibit varying levels of activity on different plants in an assemblage. Studies on the biology of *Diacrisis oblique* on different host plants demonstrated significant differences in growth and fecundity of the pest (Shaw et al. 1988). Similar results have been reported in respect of *Heliothis armigera* (Bilapate 1988). The type of vegetation in a field also affects the activities of the natural enemies of insect pests. In Israel, the cottony cushion scale, *leery a purchasi*, was found to be resistant to predation by *Rodolia cardinals* on *Spartum junceum* and *Erythrina corallodendrum* plants (Mendel et al. 1988), whereas the predator is known to be an efficient biocontrol agent of the scale on other plants elsewhere.

Diversity does not always result in reduced pest populations. It appears to be pest specific and also site specific, as well as being affected by other factors. Weed diversity reduced the incidence of fall armyworm, *Spodoptera frugiperda,* but not of the earworm, *Herliothis zea,* in a corn field (Altieri and Whitcomb 1980). The intensity of *Trachylepida* sp attack on *Cassia fistula* seeds was less in isolated plants as compared with that in mixed stands (Bhatta and Bhatnagar 1986), indicating that diversity does not always result in a reduction in pest attack.

Many multipurpose woody perennials used in agroforestry possess the inherent properties of wild plants, including genetic diversity, as they have not been domesticated for a long time and have not been subjected to rigorous genetic selection, unlike most other plants of economic importance. Before species considered for agroforestry are subjected to breeding for improvement, their insect-resistance characters should be studied in different provenances.

2.2 Taxonomic alliance

Plants belonging to the same or a very close taxonomic group have the tendency to share common pests. In agroforestry systems, aligophagous and polyphagous insect pests are expected to thrive if both components belong to the same or a closely allied taxonomic group. A large number of plants considered for agroforestry are legumes. Combining crops such as pulses or some oilseeds with leguminous woody perennials may result in supporting pest populations common to both components. The most common example is that of the bruchids. Species of caryedon beetles such as *Caryedon serratus* infest groundnut as well as a number of legume tree seeds. During the early establishment phase of agroforestry systems, tree components are likely to suffer the major injury with attack of the seeds in the limited pods produced. Later, the crops are likely to be more affected as the bruchid populations built up on the tree seeds begin to infest the pulse crops. The damage caused by the pod borer, *Etiella zinckelia*, in peas has been reported to be accentuated by the presence of acacia trees in the vicinity, as reported by Szeoke and Takacs (1984).

Plant species belonging to the same taxonomic group may contain common or closely related biochemicals that are sought by the insect pests. An insect feeding on a plant with a certain biochemical make-up will adapt more easily to closely related plants with similar biochemical constituents than to species that have entirely different constituents because of taxonomic differences. An agroforestry system comprising plant species belonging to different taxonomic groups is expected to be less affected by insect pests than a system composed of closely related species.

The availability of food over an extended period afforded by closely related plants in the agroforestry field contributes to multiplication of pest populations. The perennial plants in the system may provide a year-round food supply for the pests and thus favour maintenance of the pest population between seasons when the main food—the crop—is absent from the field. It will also result in the maintenance of the population of the pests' natural enemies.

Thus, when considering species for agroforestry, it is advisable to include plants from different taxonomic groups to avoid sharing common pests. The advantages accruing from the maintenance of natural-enemy populations also need to be weighed up.

2.3 Non-taxonomic alliance

Under natural conditions, even insects with a limited host range have been observed to feed on taxonomically diverse species of plants. Thus, taxonomically distant plant species could also be hosts for insect pests. Cocoa grown under leucaena shade suffered more from attacks of defoliating Lepidoptera than when it was grown under some forest trees because the pests were able to use leucaena as an alternative food source (Room and Smith 1975). Eucalyptus grown as shade trees with tea shares attack by *Chrysolampra flavipes* in Assam, India (Gope 1985). Cross infestation of cassava mites, *Tetranychus* spp, on banana and of thrips, *Retithrips syriacus,* on leucaena have been reported by Ghosh et al. (1986). In Hawaii, the thrips, *Frankliniella occidentalis,* which is a vector of spotted wilt virus on lettuce, tomato, cabbage, etc., occurred on leucaena blossom (Yudin et al. 1986). The bagworm, *Oiketicus kirbyi,* a pest of coffee, has been demonstrated to develop on eucalyptus leaves in Brazil (Arce et al. 1987). In an agroforestry system, therefore, the plant assembly should consist of species that do not double as host for insect pests of other plants in the system—whether crops or woody perennials.

Some insects utilize different host plants as food in their larval stages from those eaten in the adult stage. Thus an even greater range of plants in an agroforestry system may be attacked by different stages of an insect pest. A plant believed to be a non-host for an insect pest in one stage may turn out to be a host plant for another stage. An example of such a situation occurs in the co-cultivation of crops such as pearlmillet, cowpea, greengram, mothbean and sesame with such tree species as *Prosopis cineraria, Azadirachta indica* and *Zizyphus* spp in the rainy season in semi-arid regions of India. The woody species are host plants for adult chafer beetles *(Lachnosterna* spp, *Holotrichia* spp, *Anomala* spp, *Adoretus* spp and others) whose larvae cause heavy losses to these rainy-season crops in some areas. The presence of such host plants in the crop fields serves to attract the adult beetles. Although the feeding time on the woody plants is very short, the eggs released by the gravid beetles hatch into white grubs, which infest the crops, causing heavy losses.

The insect vectors of plant diseases often survive on a variety of host plants that are not taxonomically close. White flies (aleurodids) and some aphid and jassid species that are vectors of viral, bacterial and other plant diseases often attack a number of different types of plants. The diseases may not affect all these collateral or refuge hosts, but the survival and multiplication of the carrier insect is favoured by them. The presence of refuge host plants in an agroforestry system may provide a source of infection for the crops or human beings if the plant harbours vectors that spread human disease.

The presence of component plants in a system that may serve as host to a vulnerable stage of the insect pest, or that act as a collateral host for plant, animal or human disease, may be utilized to trap and kill these insects while keeping the main crop untreated. Such plants are, however, different from trap plants that are specifically grown to attract insects from the main crop and are not otherwise a component of the agroforestry system.

When establishing an agroforestry system, it is useful to consider whether the component plants serve as host to any vulnerable stage of an important insect pest of the other component plants or as collateral or refuge hosts for the vectors of diseases. Exclusion of such plants from the system could help minimize insect and disease attack on crops or woody perennials.

2.4 The host range of pests

The severity of pest infestation in an agroforestry system will depend on the host range of the attacking pests and their relative abundance in the system. Insects with a wide host range will be able to multiply on a number of host plants, while monophagous insects will be restricted to a limited number of host plants within the system. If all or most plants in a mixed system are palatable to a polyphagous pest, then it is likely that the insect will stay longer and become more numerous, causing greater damage (Speight 1983). Populations of *Empoasca krameri* were reduced when beans were interplanted with non-host grasses (Altieri et al. 1977; but were not affected by the presence of *Amaranthus dubius.* The abundance of the leafhopper *Scaphytopius acutus* increased in peach orchards when the ground cover consisted of host plants but was not affected when a non-host grass was used.

If the insect is a relatively specialized feeder, the population density will be lower in plant communities with a higher diversity. On the other hand, the more general pests are likely to increase in abundance if increasing plant diversity in an agroforestry field increases the number of potential host plants in the system. Even for relatively oligophagous pests, increasing diversity may provide a greater number of suitable hosts and lead to increased abundance. A hypothesis to explain lower numbers of herbivores in diverse plant communities proposes that the rate of emigration, rather than the rate of colonization, is the factor most affected by the presence of non-host plants in the system. Studies of various leaf beetles indicate that they have a shorter residence time in plant patches with non-host plants and move farther after encountering a non-host plant (Bach 1980a, b; Risch 1980,1981). Saxena and Basit (1982) found that both colonization and residence time of the leafhopper *Amrasca devastans* on a host plant were influenced by the presence of the non-host plants.

The presence of non-host plants in an agroforestry system is of paramount importance in managing pests. In fact, the major variable determining herbivore abundance is the ratio of host to non-host plants rather than the actual number of plant species in an agroforestry system. Through entomological investigations it is possible to manipulate the proportions of host and non-host plants in any agroforestry system. Intelligent manipulation of crop and woody-perennial combinations can minimize insect damage in an agroforestry system.

Monophagous pests can be controlled altogether by not including their host plants in the system. The host range of oligophagous and polyphagous pests can also be narrowed by eliminating palatable species from the assemblage and replacing them with non-host plants. Monophagous pests are most easily managed in this way. In a review of polyculture systems, Andow (1983a) reported that monophagous herbivores are more likely to decrease in diverse systems than polyphagous pests (61.3% versus 27.1%) and less likely to increase (10% versus 43.8%).

2.5 **Biological** control potential

Agroforestry systems, particularly the complex ones, have a great potential for controlling pest populations through increasing the efficiency of biological control agents. The natural-enemy hypothesis proposed by Root (1973) to explain reduced herbivory in polyculture systems has been tested in a large number of field experiments and the results were mostly supportive of this hypothesis. Polycultural systems such as agroforestry offer alternate prey, nectar sources and suitable micro-habitats for parasitoids and predators. Being perennial, these systems support the natural enemy population within and between seasons, especially during the off season of the main crop.

Greater colonization and abundance of natural enemies in a mixed culture of plants has been demonstrated in many experiments. Smith (1969) studied the colonization of a brussels sprouts field by *Anthocorus nemorum* with and without weedy vegetation. The predators were more abundant in samples from weedy areas (representing diverse vegetation). Rapid colonization or higher densities of predator species in dense vegetation have been reported by Sprenkel et al. (1979) and Horn (1981). Letourneau and Altieri (1983) and Letourneau (1990) suggested that predator-colonization rates could be manipulated through vegetational diversification of the crop habitat. Similarly, an increase in the diversity of tree species might increase food sources for adult parasitoids (Mendel 1988).

The presence of alternate prey associated with non-crop vegetation can prevent the local extinction of predator species (Doutt and Nakata 1973) or increase the proximity of colonizer sources (Flaherty 1969). The population of *Plutella maculipennis* on cabbage raised with a background vegetation of *Crataegus* sp was regulated by the parasitic wasp *Horogenus* sp, for which the background vegetation served as an alternate host (van Emden 1965). The predating activities of ground beetles were enhanced when cabbage was undersown with white and red clover, resulting in regulation of populations of *Erioischia brassicae, Brevicoryne brassicae* and *Pieris rapae* (Dempster and Coaker 1974). Regulation of populations of *Mamestra brassicae, Evergastis forficalis* and *Brevicoryne brassicae* due to predator enhancement as a result of co-cultivation of brussels sprouts with *Spergula arvensis* has been reported by Theunissen and den Ouden (1980). Increased abundance of predators in collards with a weedy background checked the growth of *Myzus persicae* (Horn 1981). A greater potential for pest control in complex systems as compared with simple ones was demonstrated by an increased colonization rate by a generalist predator in experiments involving the flower thrip *Frankliniella occidentalis* and the predator bug *Orius tristicolor* (Letourneau 1990). The same author reported increased visits of hymenopteran parasitoids in mixed-crop assemblages as compared with pure stands of squash.

Polycultures, especially those containing flowering trees and shrubs, can provide more pollen and nectar sources attractive to and sustaining predators than monocultures. *Ageratwn conysoides* bears flowers all year round, providing pollen for mites and favouring colonization and build up in citrus orchards (Mai et al. 1979). Introduction of flowering perennials or short-lived plants in an agroforestry system will contribute towards biological control of pests.

Some plants produce chemicals that enhance the efficacy of predators. Parasitization of corn earworm eggs by wild *Trichogramma* sp wasps was promoted by applying extracts of the weed *Amaranthus* sp (Altieri et al. 1983). The presence of these plants that increase the predatory activities of insects by virtue of producing such chemicals will benefit an agroforestry system. The parasitization of *Cotesis kazak* was more serious on *Heliothis armigera* larvae feeding on cotton, okra and tomato, than on those feeding on chickpea, pigeonpea, cowpea and dolichos bean under similar circumstances (Jalali et al. 1988).

A major factor determining natural-enemy abundance in mixed vegetation is the suitability of the microhabitat provided by one or more of the plants in the assemblage. Trees and shrubs often provide better shelter and mating sites than do short-lived annual plants. Hedges provide very favourable environments for parasitic Hymenoptera and Diptera. The Braconidae tend to colonize the leeward side of hedges and other thick vegetation, while the Vespidae and some Diptera accumulate more on the windward side (Pasek 1988). These plants also provide pupation, mating and over-wintering sites for natural enemies. Many predatory spiders prefer to inhabitate woody plants rather than annual plants. The web density of the spider *Stegduphus sarasinerum* was higher on such plants as *Acacia tortilis, Prosopis cineraria, Capparis* sp, *Tecomella* spp and *Zizyphus* spp (Chandra 1987) than on less woody species.

The presence of different herbivores in an agroforestry system may encourage predators to remain when their main prey is rare. Prey densities that fall below a certain threshold may cause emigration of natural enemies from an area. It is, therefore, important that prey availability is maintained in the system. Predators often have a wider host range than parasites and thus have a better chance of survival in the event of the population of the main prey falling to a low level.

2.6 Microclimate

The interactions among plants in a mixed agroforestry system create a micro-environment that is different from that of the surrounding area. Shade is the most prominent consequence of tree-crop combinations and it may have both a direct and an indirect effect on the activity of pests and natural enemies. Among other effects, shade provides protection from direct sunlight and regulation of light intensity underneath the tree. Reduction in temperature and an increase in humidity are indirect effects. Most diurnal insects, especially soft-bodied larval stages, prefer to feed while avoiding direct exposure to the sun. Under shady conditions their feeding activity could be enhanced, thus increasing their damage potential. Light intensity governs the habitation of fields by some dung beetles (Doube 1983). Most aphid species prefer shady conditions in the warm climates. Some pests prefer sunny conditions. Risch (1981) observed that the density of beetles on beans under the shade of maize plants was less than on beans in monoculture. Infestation by *Polyura naraea* was higher on stands at the edges of forest canopy facing the sun than on the shady side (Zhou et al. 1985). Shade from trees can interfere with the host-seeking and reproductive behaviour of some insects (Risch 1981; Yang et al. 1988). Many hymenopteran parasites exhibit greater host-searching capacity under bright-light conditions, so their activity may be retarded in the shade. Whether shade has a positive or a negative effect on pest activity depends on the habits of the pests in the agroforestry system. The shade intensity will depend on the growth habits, structure and arrangement of the trees in the system.

The humid conditions in an agroforestry system may be favourable for the development of disease in insect pests. Coupled with the absence of direct sun, the effectiveness of entomopathogenic fungi may be increased by humidity (Jaques 1983). In experiments on the effect of sunlight on the field persistence of *Nomuraea rileyi*, Fargues et al. (1988) found that the half-life and viability of spores of this fungus were much longer in the shade. The effective infective period of *Bacillus thuringiensis,* the most widely used entomopathogenic bacterial preparation, is greatly reduced in sunlight. Increased humidity has also been reported to favour parasitization of pest eggs by *Trichogramma* sp (Pu 1978).

2.7 Masking effect

Many plants emit volatile chemicals or odours into the environment. These odours are perceived by herbivorous insects and utilized to orient themselves to the host fields. Onion flies, *Hylemya antigua,* have been found to fly directly towards the odour released by an onion bait (Dindonis and Miller 1980). In monocultures, the odours released by the plants spread out in all directions and are perceived by the herbivores without any interruption. But in mixed vegetation, the odours released by some plants may mask the effect of those released by other plants. Under these circumstances, the insects find it difficult to locate the hosts on which to feed and reproduce (Altieri 1986).

Thus, odoriferous plants, when raised with host plants of insect pests, can deter recognition, feeding and reproduction of the pests on their host plants (Dethier et al. 1960; Schoonhoven 1968). Tahvanainen and Root (1972) attributed the lower density of *Phyllotreta cruciferae* on cabbage raised with tomato, tobacco and ragweed to feeding inhibition by odours from the non-host plants. The lower activity of *Plutella xylostella* on cabbage intercropped with tomato has been attributed to the repellent effect of the chemical produced by the companion crops. Many plant residues contain allelopathic compounds that could affect the growth of adjoining plants in a mixture, changing the attractiveness of the plants to their pests (Steinsiek et al. 1982). In experiments with living mulches, Altieri et al. (1990) observed lower aphid colonization and population build-up on collards grown with vetch (which they suspected to contain allelopathic compounds) as compared with that on collards in monoculture plots.

The masking effect is not restricted to the insect pests. The performance of natural enemies may also be affected by chemical cues from the associated plants (Altieri, Lewis et al. 1981; Nordlund et al. 1988). The prey-seeking behaviour of insect pests that utilize the odours of the host plants of their prey to locate them is influenced by the presence of other vegetation in the system (Monteith 1960; Shahjahan and Streams 1973). Such a situation will reduce the biological-control potential of the system. However, there could also be cues from companion plants that help establish natural enemies in the system. Identification of the plants that release pest-antagonistic and natural-enemy-attractive odours may be of great importance in developing a pest-free agroforestry system.

2.8 Barrier effects

The tall woody plants in an agroforestry system act as a physical barrier to the movement of insects to, from and within the system. The non-host plants of insect pests raised with their host plants act as biological barriers, restricting their movement towards the host plants. Hedges, boundary plantations and windbreaks affect the colonization and dispersal of both herbivorous and predatory parasitic insects. Both horizontal and vertical movements of insects are affected by tall or thick woody plantations (Pasek 1988). The permeability of the vegetation affects the movement of insects in and out of the system. In-and-out migration patterns of insects in polycultures have been studied by Bach (1984), Risch (1981), and Wetzler and Risch (1984).

Non-host plants mixed in with host plants either act as a mechanical barrier to the dispersal of the insect pest (Kennedy et al. 1959; Root 1973) or physically repel the pests because of unpleasant morphological features such as hairy leaves (Levin 1973). Weakly flying insects such as aphids, thrips, flies and small beetles are carried far afield by the wind. Once in the air, these insects cannot land directly on their host-plant plots because of the high speed of the wind carrying them. They utilize tall trees as obstructions to settle on and later move to the crop fields. Thus, the trees in an agroforestry system may serve as agents for facilitating colonization of insect pests by providing a platform from which they initiate flight to infest the crops.

The woody plants in hedges and boundaries serve as reservoirs for insects (van Emden 1965; Lewis 1969a; Solomon 1981; Onillon 1988). The most abundant taxa within hedges are parasitic Hymenoptera and Diptera. Although hedges contribute to maintaining some populations of insects, most of the increase in insect density results from insects blown in from elsewhere. The Braconidae tend to accumulate on the leeward side, while the Aphididae, Vespidae, large Diptera and Lepidoptera predominate on the windward side (Pasek 1988).

Whether they act as physical or biological barriers, the woody species in an agroforestry system will restrict the movement of insects through the system. This situation is advantageous if the entry of the insect pests is blocked or if outward movement of the natural enemies of the pests is hindered.

2.9 Field configuration and design

Some insect species, while flying high in the air, recognize their host plants by the field configuration. The configuration of a land unit is determined by the type of plants, their colour, structure, height, density in the field and the type and colour of the soil in the background. Any change in these characters may change the configuration of the field, which will affect its recognition by the insects. Dempster and Coaker (1974) observed that even small changes in cropping practices can greatly alter the attractiveness of plots to pests and their natural enemies.

Through the introduction of heterogeneity in a field, it is possible to reduce the number of insect visitors to the field. Heterogeneity can be introduced into the field in several ways, such as through changes in plant density or by mixing different types of plants. The companion crops provide a camouflage for the host crops (Altieri and Liebman 1986), thus preventing the pests from recognizing the host from a distance. Some pests prefer plants of a particular colour or texture (Cromartie 1981). In the Philippines, corn borers were found to avoid a green colour on the ground in corn fields (IRRI 1974). Aphids were found to colonize plants more readily when they stood against a background of bare soil (Kring 1972). The attractiveness of collards to aphids decreased when these were grown against a vetch background (Altieri et al. 1990). Smith (1976a) found that colonization of *Pieris rapae* on brussels sprouts was reduced when weeds were allowed to grow with the crop. Similar observations have been reported by Dempster (1969). Dempster and Coaker (1974) found that the colonization of cabbages by *Erioischia brassicae, Brevicoryne brassicae* and *Pieris rapae* was greatly interfered with when the cabbages were undersown with white and red clover. Colonization of brussels sprouts by *Mamestra brassicae, Evergestis forficalis* and *Brevicoryne brassicae* was adversely affected when the crop was grown with *Spergula arvensis* (Theunissen and den Ouden 1980), probably because of a configurational difference.

Plant-community structures also affect the biology of herbivorous insects and their natural enemies. The number of eggs laid by the pyralid, *Cactoblastis cactorum,* was affected by plant size, cladode condition, the conspicuousness of the plant, and height above ground (Robertson 1987). Leigh et al. (1974) found plant density to be positively correlated with densities of the predator *Orius tristicolor* in cotton fields. Carabaeid beetles were more destructive of *Pieris rapae* caterpillars in weedy plots than in the weeded plots of brussels sprouts (Dempster 1969).

The arrangement of the different plant species in an agroforestry system may have a profound effect on the activities of insect pests and their enemies. The situation of the crops and woody perennials with respect to the direction of wind and sun determines the effect of these agencies on the dynamics of visiting insects. The effect of shading should be minimal in systems where trees have been planted in alignment with the sun's path. Crops raised on the windward side of boundary plantations are less likely to be infested by insect species that are carried by wind.

The design of an agroforestry system will define the extent of the influence of weather on insects. The effect will be the least in systems that have thick vegetation vertically and horizontally. The pest situation in agroforestry may be manipulated through suitable design of systems so that the conditions are favourable for the predatory insects and unfavourable for the pests. The size and density of plants and their relative arrangement in time and space will determine the sphere of activity of the insects.

2.10 Exotic plants and pests

Plants with desirable attributes are often moved from one place to another. In the absence of proper phytosanitary measures and non-compliance with quarantine rules, these plants carry their pests with them to areas where they did not occur previously. In the absence of natural enemies at the new location, these insect species rapidly multiply and establish themselves as serious pests in the new location. The psyllid *Ctenartaina eucalypti,* the curculionid *Gonipterus scutellatus* and the cerambycid *Phorocantha semipunctata* have moved with eucalyptus and established themselves where the tree was introduced (Cadahia 1986). The margarodid *Auloicerya acaciae* was accidentally introduced into Australia, where it became established on a number of acacia species (Gullan 1986). The Australian sawfly, *Phylecteophaga froggati,* is causing damage to oak and eucalyptus in New Zealand (Nuttall 1985). Of the 500 species recorded on agricultural crops and forestry plantations in the former USSR, aproximately 80 were introduced insects (Konstantinova and Gura 1986). In Africa, *Rastrococcus invadens* is becoming established on horticultural and forest plants after its introduction with plant material (Agounke et al. 1988).

When an exotic plant is introduced into a locality, it may affect or be affected by the local insect fauna in a number of ways:

- The introduced plant may become a host for established pests in the area. After it was introduced into Australia, *Delonix regia* became a host to the longicorn *Aridaeus thoracicus,* a local pest of pear (Hawkeswood 1985). *Acacia tortilis,* an introduced plant in India, is attacked by a local pest, *Julodis* sp, in desert areas. A number of local insects have adapted to eucalyptus in areas where it has been introduced all over the world (Cadahia 1986). In Hawaii, the thrips *Frankliniella occidentalis* became established on leucaena after the introduction of the latter on the island (Yudin et al. 1986).
- The introduced plant may become a suitable host for insect species that were not considered important pests on local plants. When such insects multiply and establish on the exotic plant, they acquire the status of pests. Before the introduction of eucalyptus into India, *Celosterna scabrator* was considered a minor pest affecting the acacias. It adapted to eucalyptus and is now considered an important pest on that genus (Chatterjee et al. 1987).
- Exotic plant materials may bring with them some of the pest insects from their native habitat. Or the insects may arrive accidentally in the area where the exotic plant is introduced. In the absence of natural enemies at the new locations, these insects may multiply very fast and become established as major pests. *Leucaena leucocephala,* introduced in several parts of the world, is heavily infested by the psyllid *Heteropsylla cubana,* which arrived accidentally at the new sites. The cypress aphid, *Cinara cupressi,* is causing extensive damage to cypress in Africa.
- An exotic pest coming in with exotic plant material or being accidentally introduced later may establish on other plants in the location in addition to the original host plant. The leucaena psyllid, *Heteropsylla cubana,* has been found feeding on *Samania soman* in Asia.

When an exotic plant is introduced in a locality, there may be an interval before it begins to be attacked by insects. It is necessary to observe the plant for at least two years before the insect fauna establishing on it can be determined.

2.11 Domestication of plants

A number of woody plants used in agroforestry have not been improved. In their natural habitats they withstand insect attack through in-built characteristics such as predator satiation and natural resistance. When these plants are brought into agroforestry/ the naturally occurring insects can now be considered pests as each plant acquires economic significance.

Introduced non-domesticated woody plants can sometimes become pests—that is, weeds. The woody plants that flower and fruit early and profusely may disseminate their seeds in the crops and interfere with their growth. Leucaena plants have this tendency and have already become weeds in some high-rainfall areas. Such plants are best pruned before flowering or fruiting to avoid dissemination of the seeds to cropped areas. The insect species that are pests on these woody plants turned weeds may be used as biocontrol agents in the affected areas. Many acacias introduced to Australia and South Africa have become weeds, and farmers are seeking to control them using insects. Some species of sesbania are also considered weeds in South Africa. Insects acquire additional significance under such conditions.

2.12 Tree-crop competition and nutrition

The component plants in a mixed system vie for essential resources. Although agroforestry is envisaged as a system of plant species that benefit each other mutually or unilaterally, it is too optimistic to assume that all types of competition can be eliminated in these systems, especially in areas with poor soils and scanty rainfall. Agroforestry systems lose some of the assimilated nutrients in the form of grain, wood, fodder, etc., at each harvest, thus reducing reserves, unlike natural forests where recycling of nutrients occurs. Insects play an important role in removing plant materials from agroforestry systems. In studies with *Leucaena leucocephala, Gliricidia sepium* and *Flemingia* sp leaf mulches, Budelman (1988) found that soil-dwelling insects and other arthropods were responsible for considerable losses of mulch. Reviewing various hypotheses concerning the advantages of insect herbivores for plants, Lamb (1985) concluded that high levels of herbivory are unlikely to be nutritionally beneficial to the grazed plants.

The general condition of a plant affects its susceptibility to insect attack. Termites preferentially attack water-stressed plants or those stressed in other ways, although they sometimes also attack healthy plants. The same level of infestation may bring about different degrees of injury in the healthy and stressed plants. Tuset and Hinarejos (1985) observed that water stress increases susceptibility to bark invasion by *Pestalotiopsis junerea* in cypress and palms. Leaf toughness in eucalyptus influenced population build-up of the chrysomelid beetle *Paropsis atomaria* (Ohmart et al. 1987).

Nutrient concentration affects the attractiveness of plants to invaders. Ohmart et al. (1985) found that nitrogen plays an important role in the population dynamics of chrysomelid beetles on eucalyptus. In agroforestry, nitrogen-fixing trees make available more nitrogen to the crop components, which may enhance their attractiveness to insect pests. Mycorrhizal inoculation may partly take care of phosphorus utilization, but other nutrients and micronutrients may have to be supplemented to counter the effects of excessive nitrogen levels from a pest-control point of view.

2.13 Management practices

The agronomic practices involved in agroforestry system management may affect the activities of pests and their natural enemies. An undisturbed system favours the establishment of a stable pest-natural enemy equilibrium. In intensely managed systems the parasites and predators are more likely to be disturbed than the pests. Emigration of the natural enemies as a result of disturbances may lessen the benefits of biological control in the system.

Mulches in an agroforestry field may serve as a source of food for many soil-dwelling insects. Budelman (1988) observed that a large part of the mulch was destroyed by soil-dwelling arthropods before it decomposed.

Severe pruning of plants in alley cropping gives rise to new vegetative growth, which is more palatable to the insects than the older growth. Removal of infested plant parts by pruning may help to get rid of sessile sucking pests. Fallowing part or the whole of a unit of land affects insect abundance in the unit, especially of the soil-dwelling stages. Intensification of fallow resulted in increased grasshopper numbers, while cultivation and afforestation affected the grasshoppers adversely in investigations carried out by Amatobi et al. (1988).

3 Strategies for pest management in agroforestry

There are inherent advantages in agroforestry from an insect-pest management point of view. In order to get the most out of these practices, the features of an agroforestry system that influence insect pests should be suitably manipulated. A properly designed agroforestry system with the right choice of components can create conditions that are favourable for natural enemies of the insect pests and unfavourable for the latter. The establishment of an environment-friendly agroforestry system requires that the following factors be taken into account.

3.1 Choice of species

To introduce selective diversity in an agroforestry system, the plants chosen should be taxonomically far apart, have a narrow pest complex and have resistant strains. The mix of species in the assemblage should be altered until the right combination of plants is obtained as indicated by a reduced number of pests and an increased number of predators. Such a system would be stable from the insect-pest point of view.

3.2 Microclimate

When introduced into a land unit, trees create a microclimate in the area that is different from that of the surrounding areas. Depending on the tree species chosen (whether erect, spreading, with a thick or thin canopy cover, etc.) and the crops underneath, a microclimate of the desired type can be created for the agroforestry system. The choice of tree species is determined by the requirements of the crops concerned. Systems with multistrata vegetation are expected to favour the development of food webs, thus creating a stable pest-parasite equilibrium.

3.3 Field configuration and design

The arrangement of crops and woody perennials in an agroforestry system affects the activity of insect pests and their natural enemies. By planting trees in line with the direction of the sun's path, the shading effect can be minimized, while planting perpendicularly to the sun's rays will give maximum shading. Where the trees are planted will depend on whether the crops require shade or sunlight. Plants aligned in the direction of the wind will let insects pass through the field, while those aligned across the wind direction will shield the field.

3.4 Introduction of barriers

Large trees act as barriers to the movement of wind and insects in a field. The non-host plants may also act as a barrier to pests. These may be planted in broad strips along with the host plants. Thick hedges around the field define the boundaries for the movement of natural enemies of the pests. Preferably hedges should be of flower-bearing plants to provide food for the natural enemies.

3.5 Odoriferous plants

Introduction of a variety of odour-emitting plants in an agroforestry system may help to divert the major pests if they are guided by odours. The system can be planned to include plants that would repel the pests of companion crops.

3.6 Trap plants

In the case of some pests, the main crop or woody plant may be protected from attack by insect pests by growing a more palatable plant with it. Such 'trap' plants may or may not be component plants of the system but serve to divert the pests from settling on the main crops.

3.7 Management practices

The practices for management of an agroforestry system need to be developed or modified with a view to minimizing insect-pest incidence and injury. Depending on the habits of the major insect pests in the system, agronomic practices may be tailored to discourage the pests and to favour the predators and parasites.

There are several ways in which pest populations may be kept down in an agroforestry system, though it is difficult to test all of them in the field. The practitioner can develop an effective package after trying different practices.

4 Insects associated with multipurpose trees and shrubs

4.1 Literature retrieval

An agroforestry system consists of at least of two components, the crop component and the woody component. A large number of trees and shrubs are used as woody perennials with local crops in different agroforestry systems. There have been many studies on the insect pests of crops, but little or no information is available on the insect pests of the woody perennials that are important components in most agroforestry systems. This may be because these plants were not considered economically important when they occurred only in their natural stands. In agroforestry systems, in which woody plants and crops are grown together, the insect pests of one component can affect those of the other. It is, therefore, essential to know about the insect pests of each component plant in the assemblage. Because information about insect pests is available for most of the crops used in agroforestry systems, this study concentrated on the insects associated with some commonly used multipurpose trees and shrubs.

The list of insects presented in appendix 1 was compiled from a detailed literature search. The sources are indicated at the end of this section. The number of references used to compile these lists is large; therefore only the primary sources are listed. The abstracts and titles in different databases and in the annotated lists did not always contain enough detail about the pests' taxonomy, nature of damage and status, etc. In such cases, the type of injury indicated in the appendix is based on the injury normally caused by the species or genus on other hosts, or on the basis of characteristic family habits. The exact type of injury inflicted on any host under different ecogeographical conditions needs to be confirmed for each insect species.

There have been many changes in the taxonomic status of various insects in the last 20 years—many new families have been raised and there have also been changes in generic and specific nomenclature, besides reorganization of some species into different families or subfamilies. Thus an insect included in a particular family in the older literature may well be in another family in later works. The lists of insects associated with multipurpose trees and shrubs presented in the appendix are based on a limited literature survey and are, therefore, not exhaustive.

4.2 Field observations

During the field visits to different AFRENA sites and the ICRAF Machakos Research Station, a number of insect pests and their natural enemies were collected from woody plants (appendix 2). The worst hit plants were *Cajanus* *cajan, Cassia siamea, Erythrina* spp and *Sesbania sesban.* Pigeonpea at Machakos suffered heavy insect attack, the most serious being that of the shoot scale, *Coccus longulus.* These scale insects were found to be attended by the ant, *Pheidole megacephaly,* which protected them from natural enemies and also helped in their spread and establishment on uninfected plants. The affected plants dried up. Secondary infestation by termites on scale-affected plants was observed. The incidence of termites was low on healthy plants but it was heavy on cocci-infested plants. If the ants were removed from the cocci-infested shoots, a parasitoid complex consisting of *Metaphycus stanleyi, Eupelmus* sp, *Cheiloneurus carinatus* and *Tremblaya minor* quickly developed on the cocci colonies. The development and spread of coccids could be curtailed by preventing ants from nursing the cocci colonies. A number of pod-borer insects were observed, but not all of these could be reared. Further investigations on the cocci-parasitoid complex could yield useful results.

In Cameroon, pigeonpea plants were seriously infested by the spittle bug, *Ptyelus grossus,* which fed gregariously in a ring around the shoot, resulting in the entire shoot drying up, from the point of infestation upwards. Another serious insect pest on pigeonpea in Cameroon was a stem borer, which attacked the plants 10-30 cm from the ground. The infested plants dried up. We were unable to rear the borer larvae to the adult stage; therefore the pest remains unidentified. These two insect pests on pigeonpea in Cameroon need further study.

Calliandra calothyrsus plants at Machakos were prone to attack by a number of insect pests. The most tmportant of these was a cossid borer, which inflicted heavy injury on plants in agroforestry trials. Again, we were unable to rear it to the adult stage during the period of the fellowship; hence it remains unidentified. A severe attack of mealy bug, *Spilococcus* sp, was observed in Machakos. The spread of this insect was very rapid. The leaves of affected plants dried up. The mealy bugs were attended by the ant *Pheidole megacephaly.* When the ants were removed from the mealybug colonies, a predator-parasite complex quickly developed. *Leucopsis* sp and *Nephus* sp were recorded as predators on *Spilococcus* sp. The parasitoid complex consisted of *Anagrys nigrescens, Cheiloneurus carinatus, Pseudectroma* sp, *Aprostocetus* sp and *Pachyneuron* sp. There is a need to make further observations on the pest-parasite complex, as it carries enormous scope for biocontrol studies on this pest. Further studies are also required on the cossid borer.

Characteristically, *Erythrina* spp are attacked by a number of insect-pest Species. Leaf skeletonizing was very common, though the responsible insects were not collected during the visits. Gall insects were also observed. Many sucking insects were observed on leaves and shoots. *Erythrina poeppigiana* plants in pure stand suffered heavy damage from an unidentified shoot borer at Mashitshi in Burundi. The same plant species raised with banana in a nearby agroforestry field was free from borer attack. This was a clearcut case of agroforestry contributing to low insect-pest injury of component plants.

In all agroforestry trials in Southern and Eastern Africa AFRENA sites, *Sesbania sesban* was found to be attacked heavily by insect pests. *Mesoplatys orchroptera,* a chrysomelid beetle, defoliated plants at all stages of growth. It is a major insect pest of sesbanias in Africa. A number of other defoliators also existed on this host. At Rwerere, in Rwanda, unidentified cicadellids caused discolouration of leaflets, reducing the photosynthetic efficiency of the plants. In Butare, a complex of sucking insects was observed on sesbania plants. If sesbania plants are to find a successful place in agroforestry in Africa, effective plant-protection measures need to be devised.

Termites are a major pest at some sites, but at other places damage from them is not very serious. In Karuzi, Burundi, alnus, casuarina and grevillea plants suffered heavy termite injury during the establishment phase. Once they were established, the chance of mortality caused by termites was reduced. Termites tended to attack weakened plants; healthy plants often withstood moderate termite attack. Further studies are required to establish the role of termites in agroforestry. In some places, as at Rubona in Rwanda, the termites contributed to decomposition of mulch material without affecting the hedgerows in the agroforestry field. Mulch also contributed to population build-up of termites. If there is moisture stress and plants become weak, the termites may attack weakened plants. If there is no damage to component plants under stress conditions in an agroforestry system, but the decomposition process continues, this would be a great advantage of agroforestry practices.

The insects listed in the following tables were collected during visits to AFRENA sites and to ICRAF's Machakos Research Station. The collection was identified at the National Museums of Kenya, Nairobi, and the CAB International Institute of Entomology (HE), London. The appendix lists only those insects that were collected and preserved during visits to experimental sites. However, some of the important insect pests observed during the visits do not appear in these lists because they were not identified. Also, the list represents only those insects observed during a single visit to most experimental sites. The whole insect complex of each multipurpose tree or shrub species at each site could be much larger. More frequent visits are required to record the occurrence of different insects at different times of the year and at different stages of plant growth. A follow-up research effort along these lines could yield useful information.

4.3 Primary sources of information used to compile lists of insects associated with multipurpose trees and shrubs

AGRICOLA database on CD Rom 1970-1978 Silverplatter. USD A.

AGRICOLA database on CD Rom 1979-1984 Silverplatter. USD A.

AGRICOLA database on CD Rom 1984-Oct 1991 Silverplatter. USDA.

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Nitrogen Fixing Tree Research Reports, vol. 1-8.

5 Directions for future research

Agroforestry entomology is an important area of research, but there is little information available at present about the kinetics of insects in agroforestry systems. Each agroforestry system has its own insect problems, which may be very different from those of other systems. Therefore, each system has to be studied separately.

- Identification of the insect pests in an agroforestry system would be the first step in initiating entomological studies. Of the many insects visiting the system, the injurious insects should then be identified after ascertaining the type and extent of injury inflicted by them. This exercise must be carried out for each plant species in each component of the system. The result will be a summary of the entire pest complex in the system. The same set of observations may be utilized to identify the host range of pests within the system and the common insect pests on component plants. These observations should be maintained at fixed intervals, preferably weekly, during all seasons for two years.

  The pest complex in an agroforestry system may change with the age of the system. Therefore, continuous observations should be maintained to record the changes, if any. This may be accomplished through frequent entomological surveys and through collaboration with national, regional and international organizations and networks in the countries where studies are proposed. The insects collected from each agroforestry system in different ecoregions may be maintained at the National Museums of Kenya, ICRAF Headquarters or at any other suitable place, for reference. All stages of larval instar should be displayed with the adult stage to facilitate identification. The collections should be identified by authentic identification services.

- The key species in a pest complex must be identified for further detailed studies. Studies of the life histories of these pests need to cover seasonal incidence, peak period of activity, mode of attack, life cycle, the vulnerable stages, predators and parasites on individual insect species with the stage attacked, etc. Such studies involve both field and laboratory research. Observations should be made on the predisposing factors affecting the population build-up of pests, for example, temperature, relative humidity and sunlight. Such studies would yield data to be used for pest forecasting.

- Estimations of losses caused by insect pests on individual plant species and on the system as a whole need to be made. Whereas the losses to crops can be estimated using the standard methods employed for agricultural crops, methods of estimating losses caused by insect pests on woody perennials may have to be devised. This is because the woody plants play a different role in agroforestry than in their natural stands. For example, in an alley-cropping system for soil-fertility enhancement, the leaves of woody plants are important as they contribute to soil enrichment. Under natural conditions, or in forestry, a small loss of leaves can be ignored if growth is not affected, but in an alley-cropping system even small amounts of leaf loss are significant. Each agroforestry system may attach a different value to its component plants and therefore the method of loss estimation may be different for each system. In addition to economic criteria, the sustainability aspect should also be taken into account in loss estimations.

- Information about agroforestry insect pests may be presented in the form of an identification manual containing figures or photographs of these pests together with information about their mode of injury, distribution, host range, life cycle, natural enemies, management practices, if developed, and other pertinent information.

- Agroforestry systems have a great potential for the establishment of biocontrol agents. After obtaining preliminary information about the natural enemies of the pests in the system, further studies on biological control may be taken up in association with CAB, the International Institute of Biological Control (IIBC) and other networks in the region. Identification of multipurpose trees and shrubs that favour the population build-up of natural enemies through provision of food (pollen, nectar, etc.) could be initiated at the same time. The constraints to the establishment of natural enemies also need to be identified. In Machakos, for example, the ant, *Pheidole megacephaly,* which attend coccaids, provides them protection from predators and parasites. Removal of the ants may result in population build-up of the natural enemies and thus in checking the coccoid. Microbial agents that check pest populations may be used to advantage in pest management. Once established, these agents provide cheap long-term protection against the host insects. Trials should be initiated to test the efficacy of the microbial agents against the major pests in agroforestry systems.

- The pollinators of the insect-pollinated plants in an agroforestry system need to be identified. This is essential so that the layperson can differentiate between useful and harmful insects. The knowledge of pollinator insects is especially important in the case of MFTS that are to be transported to distant sites from their native locations. Failure of fruit setting in such plants may be associated with a lack of pollinators in the new site.

- An important area of research in agroforestry entomology will be to study the effect of interactions among components on insect dynamics. A comparison of insect abundance on a plant species in monoculture and in agroforestry will provide first-hand information about the effect of co-cultivation on insect dynamics. The mechanisms that govern the level of pest populations in agroforestry are central to understanding the dynamics of insect activities in these systems. Therefore, the variables that determine insect abundance in agroforestry need to be studied. The combined effect of all variables acting independently or with other variables also needs to be determined. The results will indicate the advantages or otherwise of agroforestry practices in pest management.

- A woody plant species being considered for agroforestry must be studied for the insects associated with it in its natural habitat, especially if it is intended to introduce it in new areas. The knowledge of the pests and their natural enemies thus acquired will be of immense importance should some of the pests travel to the new area and establish there in the absence of natural enemies. In such circumstances, the natural enemies of the pest from the native areas may be introduced to the new location to establish themselves on the host insect. The case of the leucaena psyllid illustrates the need to carry out such studies in respect of each potential multi-purpose tree and shrub species.

- A search should be initiated to identify MPTS associated with small pest complexes. Such plant species should be given priority consideration for agroforestry to reduce the risk of pest attack. Pest-tolerant provenances may be identified from among the tree and shrub species already used in agroforestry. These can also be used for tree-improvement programmes.

- Tree-improvement programmes should include insect resistance as one of their objectives. In the long term, high-yielding species or provenances may not provide as much output from the system if they are more insect prone than species with lower levels of productivity but higher insect resistance.

- There is a need to study various tree-crop combinations in different agroforestry systems for their insect-reduction capabilities. A comparison of the prevalence and extent of injury due to an insect pest on a particular host species when raised with other plant species will indicate the combinations that hinder the activity of that insect pest. Simultaneous observations should be made for all the major pests on a host species in different combinations. There could be combinations that favour some pests and inhibit others. Information from such studies would help in choosing optimal tree-crop combinations.

- The effect of different temporal and spatial arrangements of crops and woody perennials on the insect pests in an agroforestry system must also be studied. Thus, woody perennial-crop combinations and arrangements that support the minimum pest populations may be identified. Such designs should be tested at many locations before being approved for a particular agroforestry system.

- The plant species considered for agroforestry should be studied for their allelopathic characters and their ability to repel or attract major insect-pest species in the system. Inclusion of the species that repel the pests of other component species should be encouraged.

- Plant species that act as collateral or refuge hosts for the pests of crops or vectors of plant or human disease need to be identified. It may be desirable to replace such species with other suitable species.

- To develop effective pest-management programmes in agroforestry, agronomic and cultural practices that help reduce the major pest populations need to be developed. The practices that exacerbate pest injury also need to be studied so that these practices can be discouraged or discontinued, or measures can be developed to counter the ill effects of these practices.

- Integrated pest-management strategies must be devised. An ideal pest-management programme for agroforestry should entail no pestcides, or minimum use of them, but maintain pest populations below threshold levels (to be determined for each system) by integration of physical, cultural and biological control measures.

- The relevant information on insect pests and their natural enemies should be stored in a database and made available to practitioners of agroforestry. New information may be added to it periodically. Based on the knowledge thus acquired, it would then be possible to start a forecasting service on insect pests in agroforestry, in association with other agencies.

6 Conclusion

The field of agroforestry entomology is still virtually unexplored. There are vast possibilities for research in the field. In particular, not enough information is available about the insect pests in agroforestry systems in the tropics. The effect of co-cultivation of crops and trees or shrubs on insect dynamics needs to be studied in different agroforestry systems. The list of aspects that could be studied is very long. Beginning with the collection of information about the insect pests in different agroforestry systems, the many factors that are significant in the complex relationships between plants and insects in every agroforestry system should be studied in detail.

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Appendices

Appendix 1. Insects associated with multipurpose trees and shrubs — compilation from the literature

Acacia mangium

Insect species	Family	Injury
COLEOPTERA		
Leucopholis irrorata	Curculionidae	Defoliate seedlings
Myllocems sp	Scarabaeidae	Damage foliage
HETEROPTERA		
Helopeltis spp	Miridae	Suck sap
HYMENOPTERA		
Atta spp	Formicidae	Damage foliage
ISOPTERA		
Coptotermes curvignathus	Rhinotermitidae	Damage roots, trunk
Coptotermes sepangensis	Rhinotermitidae	Damage roots, trunk
Microcerotermes distans	Termitidae	Damage roots, trunk
LEPIDOPTERA		
Thosea asigna	Limacodidae	Defoliator
Cryptothelea sp	Psychidae	Defoliator
Pteroma pendula	Psychidae	Defoliator
Pteroma plagiophaleps	Psychidae	Defoliator
ORTHOPTERA		
Valanga nigricornis	Acrididae	Destroy seedlings
Nisitra vittatus	Acrididae	Destroy seedlings
Atractomorpha spp	Acrididae	Destroy seedlings

Acacia mearnsii

Insect species	Family	Injury
COLEOPTERA		
Amintinus tenuis	Bostrychidae	Tunnel stems
Apate indistincta	Bostrychidae	Tunnel stems
Apate monachus	Bostrychidae	Feed on bark, wood
Bostrychoplites cylindricus	Bostrychidae	Feed on bark, wood
Bostrychopsis villosula	Bostrychidae	Feed on bark, wood
Sinoxylon ruficorne	Bostrychidae	Bore into sapwood
Xylionopsis ukerewana	Bostrychidae	Feed under bark
Xylionopsis sp	Bostrychidae	Feed under bark
Xyloperthodes castaneipennis	Bostrychidae	Feed under bark
Xyloperthodes clavula	Bostrychidae	Feed under bark
Xylopsocus sellatus	Buprestidae	Feed under bark
Agrilus uedil	Buprestidae	Bore wood or bark
Agrilus grandis	Buprestidae	Bore wood or bark
Chrysobothris dorsata	Buprestidae	Bore wood or bark
Calcmthemis hauseri	Cerambycidae	Stem, branch borer
Chlorophorus carinatus	Cerambycidae	Stem, branch borer
Metameces suturalis	Cerambycidae	Stem, branch borer
Metameces sp	Cerambycidae	Stem, branch borer
Nosoeme clavipes	Cerambycidae	Stem, branch borer
Oemida gahani	Cerambycidae	Stem, branch borer
Peploptera bistrinotata	Clytridae	Stem, branch borer
Peploptera suturalis	Clytridae	
Epilachna usambarica	Coccinellidae	-
Aedemonus sp	Curculionidae	Defoliator
Camptorrhinus vulturnus	Curculionidae	
Hipporrhinus tenuegranosus	Curculionidae	-
Labotrachelus sp	Curculionidae	Defoliator
Nematocerus perditor	Curculionidae	Defoliator
Nematocerus productus	Curculionidae	Defoliator
Nematocerus sp	Curculionidae	Defoliator
Oreorrhinus glabricollis	Curculionidae	Defoliator
Phoromitus pilosus	Curculionidae	Defoliator
Phoromitus undaticollis	Curculionidae	Defoliator
Heteronychus andersoni	Dynastidae	Defoliator
Rhembastus sp	Eumolpidae	Larvae feed on roots
Syagrus flavescens	Eumolpidae	Defoliator
Megalognatha aenea	Galerucidae	Defoliator
Megalognatha cyanipennis	Galerucidae	Defoliator
Megalognatha imbecilla	Galerucidae	Defoliator
Megalognatha meruensis	Galerucidae	Defoliator
Megalognatha metallica	Galerucidae	Defoliator
Megalognatha pilosa	Galerucidae	Defoliator
Monolepta sp	Galerucidae	Defoliator
Lagria purpurascens	Lagriidae	Feed on seedlings, buds
Frea marshalli	Lamiidae	Wood borer
Autoserica sp	Melolonthidae	Feed on flowers, leaves
Schizonycha spp	Melolonthidae	Feed on flowers, leaves
Anome sp	Prionidae	Wood borer
Mallodon downesii	Prionidae	Wood borer
Popillia aeneipennis	Rutelidae	Defoliator
Apoglostatus acaciae	Scolytidae	Feed on bark, wood
Curimosphena fasciculosa	Tenebrionidae	Feed under bark
Eutochia pulla	Tenebrionidae	Feed under bark

Insect species	Family	Injury
Gonocephalum prolixus	Tenebrionidae	Feed under bark
Gonocephalum simplex	Tenebrionidae	Feed under bark
Gonocnemis sp	Tenebrionidae	Feed under bark
Hoplonyx nasutus	Tenebrionidae	Feed under bark
Lyphia sp	Tenebrionidae	Feed under bark
HETEROPTERA		
Campylomma sp	Miridae	Suck sap, release toxins
Lygidolon laevigatum	Miridae	Suck sap, release toxins
Lygus complexus	Miridae	Suck sap, release toxins
Rayieria sp	Miridae	Suck sap, release toxins
HOMOPTERA		
Ptyelus grossus	Cercopidae	Devitalize plant
Erythroneura sp	Cicadellidae	Suck sap
Jassus subolivaceus	Cicadellidae	Suck sap
Selenocephalus sp	Coccidae	Suck sap
Ceroplastes africanus	Coccidae	Suck sap
Coccus hesperidum	Coccidae	Suck sap
Hemiberlesia camelliae	Coccidae	Suck sap
Hemiberlesia lataniae	Coccidae	Suck sap
Hemiberlesia rapax	Coccidae	Suck sap
Icerya maxima	Coccidae	Suck sap
Pericerya purchasi	Coccidae	Suck sap
Pulvinaria jacksoni	Coccidae	Suck sap
Oxyrachis pandatus	Membracidae	Suck sap
Spalirisis alticomis	Membracidae	Suck sap
LEPIDOPTERA		
Achaea thermopera	Agrotidae	Defoliator
Phiala punctulata	Eupterotidae	-
Semiothisa fulvimargo	Geometridae	Defoliator
Gonometa drucei	Lasiocampidae	Defoliator
Gonometa fulvida	Lasiocampidae	Defoliator
Gonometa podocarpi	Lasiocampidae	Defoliator
Gonometa postica	Lasiocampidae	Defoliator
Taragama cuneatum	Lasiocampidae	Defoliator
Taragama distinguendum	Lasiocampidae	Defoliator
Coenobasis albiramosa	Limacodidae	Defoliator
Argyrostagma niobe	Lyman triidae	Defoliator
Dasychira georgiana	Lyman triidae	Defoliator
Dasychira sp	Lyman triidae	Defoliator
Orgyia vetusta	Lyman triidae	Defoliator
Neptis agatha	Nymphalidae	Defoliator
Acanthopsyche aethiops	Psychidae	Defoliator
Clania cervina	Psychidae	Defoliator
Kotochalia junodi	Psychidae	Defoliator
Manatha aethiops	Psychidae	Defoliator
Gynanisa maia	Saturnidae	Defoliator
Lobobunaea tyrrhea	Saturnidae	Defoliator
Nudaurelia tyrrhea	Saturnidae	Defoliator

Acacia tortilis

Insect species	Family	Injury
COLEOPTERA		
Sinoxylon anale	Bostrychidae	Feed on bark, wood
Sinoxylon crassum	Bostrychidae	Feed on bark, wood
Bruchidius albosparsus	Bruchidae	Destroy seeds
Bruchidius aurivillii	Bruchidae	Destroy seeds
Bruchidius petechialis	Bruchidae	Destroy seeds
Bruchidius rubicundus	Bruchidae	Destroy seeds
Bruchidius spadicus	Bruchidae	Destroy seeds
Callosobruchus chinensis	Bruchidae	Destroy seeds
Caryedon serratus	Bruchidae	Destroy seeds
Acmaeodera aurifera	Buprestidae	Bore under bark
Julodis sp	Buprestidae	Bore under bark
Stromatium barbatum	Cerambycidae	Bore stem, branches
Lyctus afriamus	Lyctidae	Destroy softwood
HOMOPTERA		
Oxyrhachis tarandus	Membracidae	Suck sap
LEPIDOPTERA		
Beralade similis	Lasiocampidae	Defoliator
Indarbela quadrinotata	Metarbelidae	Bore in forks
Auchmophila kordofensis	Psychidae	Defoliator
Cryptothelea crameri	Psychidae	Defoliator
Katochalia junodi	Psychidae	Defoliator

Albizia falcataria

Insect species	Family	Injury
COLEOPTERA		
Callimetopus sp	Cerambycidae	Bore stem, branches
Doliopygus excavatus	Platypodidae	Tunnel the wood
Leucopholis irrorata	Scarabaeidae	Defoliator
Xyleborus fornicatus	Scolytidae	Sapwood borer
HOMOPTERA		
Coccus acaciae	Coccidae	Suck sap
Coccus elongatus	Coccidae	Suck sap
Pseudococcus sp	Pseudococcidae	Suck sap
Acizzia sp	Psyllidae	Suck sap
LEPIDOPTERA		
Zeuzera coffeae	Cossidae	Bore into stem
Semiothisa sp	Geometridae	Defoliator
Sahyadrassus malabaricus	Hepialidae	Sapling borer
Ophiusa janata	Noctuidae	Defoliator
Spodoptera litura	Noctuidae	Defoliator
Catopsilia pomona	Pieridae	Defoliator
Eurema blanda	Pieridae	Defoliator
Eurema hecabe	Pieridae	Defoliator
Pteroma plagiophleps	Psychidae	Defoliator
Nudaurelia staudingeri	Saturnidae	Defoliator
Spatularia mimosae	Tineidae	Defoliator

Albizia lebbeck

Insect species	Family	Injury
COLEOPTERA		
Bruchidius sparsemaculatus	Bruchidae	Destroy seeds
Bruchidius uberatus	Bruchidae	Destroy seeds
Merobruchus paquetae	Bruchidae	Destroy seeds
Xystrocera festiva	Cerambycidae	Bore stem, branches
Xystrocera globosa	Cerambycidae	Bore stem, branches
Myllocerus spp	Curculionidae	Defoliator
Xyleborus metacuneolus	Scolytidae	Stain sapwood
HOMOPTERA		
Ceroplastes egbarutn	Coccidae	Suck sap
Ceroplastes subsphaericus	Coccidae	Suck sap
Ceroplastes ugandae	Coccidae	Suck sap
Rastrococcus iceryoides	Coccidae	Suck sap
Kerria sindica	Kerriidae	Suck sap
Oxyrhachis tarandus	Membracidae	Suck sap
Psylla oblonga	Psyllidae	Suck sap
LEPIDOPTERA		
Indarbela quadrinotata	Metarbelidae	Makes holes in branch forks

Albizia spp

Insect species	Family	Injury
COLEOPTERA		
Mecocerus sp	Anthribidae	
Phloeobius pustulosus	Anthribidae	_
Apate indistincta	Bostrychidae	Make holes in wood
Bostrychopsis mllosula	Bostrychidae	Feed on bark, wood
Xylion adustus	Bostrychidae	Feed on bark, wood
Xyloperthella crinitarsis	Bostrychidae	Feed on bark, wood
Xyloperthodes castaneipennis	Bostrychidae	Feed on bark, wood
Xylopsocus capucinus	Bostrychidae	Feed on bark, wood
Bolbocranius bicolor	Brenthidae	Larvae bore wood
Cerobates sulcirostris	Brenthidae	Larvae bore wood
Genogogus sp	Brenthidae	Larvae bore wood
Agrilus grandis	Buprestidae	Feed under bark
Agrilus hastulatus	Buprestidae	Feed under bark
Chlorophorus deterrens	Cerambycidae	Bore stem, branches
Nosoeme clavipes	Cerambycidae	Bore stem, branches
Oncideres rhodosticta	Cerambycidae	Bore stem, branches
Curanigus figuratus	Cucurlionidae	Girdle the tree
Phaenomerus sp	Cucurlionidae	Girdle the tree
Stenoscelis podocarpi	Cucurlionidae	Attack wood
Megalognatha rufiventris	Galerucidae	Defoliator
Exocentrus sp	Lamiidae	Attack the wood
Monochamus variegatus	Lamiidae	Attack the wood
Sophronica somaliensis	Lamiidae	Attack the wood
Chaetastus montanus	Platypodidae	Bore into sapwood
Doliopygus brevis	Platypodidae	Bore into sapwood
Doliopygus erichsoni	Platypodidae	Bore into sapwood
Doliopygus ghesquieri	Platypodidae	Bore into sapwood
Doliopygus serratus	Platypodidae	Bore into sapwood
Doliopygus subditivus	Platypodidae	Bore into sapwood
Doliopygus unicus	Platypodidae	Bore into sapwood
Periotnatus longicollis	Platypodidae	Girdle the tree
Platypus ater	Platypodidae	Wood borer
Platypus spinulosus	Platypodidae	Wood borer
Macrotoma natala	Prionidae	Feed under bark
Mallodon downesi	Prionidae	Feed under bark
Apoglostatus acaciae	Scolytidae	Feed on bark, wood
Hapalogenius cinchonae	Scolytidae	Feed under bark
Hapalogenius seriatus	Scolytidae	Feed under bark
Hapalogenius sp	Scolytidae	Feed under bark
Metahylesinus oblongus	Scolytidae	Feed under bark
Phloeosinus aubei	Scolytidae	Feed under bark
Scolytoplatypus kivuensis	Scolytidae	Feed under bark
Stephanoderes biseriatus	Scolytidae	Feed under bark
Traglostus exornatus	Scolytidae	Feed under bark
Xyleborus aegir	Scolytidae	Stain sapwood
HETEROFTERA		
Homoeocerus sp	Coreidae	Suck sap

Albizia spp (contd)

Insect species	Family	Injury
HOMOPTERA		
Aspidoproctus magnicornis	Coccidae	Suck sap
Aspidoproctus maximus	Coccidae	Suck sap
Hemiberlesia lataniae	Coccidae	Suck sap
Hemiberlesia tectonae	Coccidae	Suck sap
Nipaecoccus vastator	Coccidae	Suck sap
Isometopus sp	Isometopidae	Suck sap
Libyaspis sp	Plataspidae	Suck sap
Plataspis vermicillaris	Plataspidae	Suck sap
Acizzia uncatoides	Psyllidae	Suck sap
Psylla hyalina	Psyllidae	Suck sap
LEPIDOPTERA		
Aegeria leptomorpha	Aegeriidae	-
Polydesma umbricola	Agrotidae	-
Semiothisa rectistriari	Geometridae	Defoliator
Taragama basale	Lasiocampidae	Defoliator
Anthene definita	Lycaenidae	Defoliator
Veudorix antdlus	Lycaenidae	Defoliator
Phlyaria cyara	Lycaenidae	Defoliator
Dasychira ila	Lyman triidae	Defoliator
Indarbela spp	Metarbelidae	Hole the forks
Salagena atridiscata	Metarbelidae	Hole the forks
Epanaphe moloneyi	Notodontidae	Defoliator
Phalera grotei	Notodontidae	Defoliator
Charaxes viola	Nymphalidae	Defoliator
Neptis agatha	Nymphalidae	Defoliator
Eurema blands	Pieridae	Defoliator
Eurema hecabe senegalensis	Pieridae	Defoliator
Homadaula anisocentra	Plutellidae	Defoliator
Imbrasia nictitans	Saturniidae	Defoliator
Laspeyresia sp	Tortricidae	Defoliator

Insect species	Family	Injury
COLEOPTERA		
Lasioderma sp	Anobiidae	-
Apriona spp	Cerambycidae	Bores trunk, branches
Batocera spp	Cerambycidae	Bores trunk, branches
Oemida gahni	Cerambycidae	Bores trunk, branches
Sthenias grisator	Cerambycidae	Bores trunk, branches
Hypomeces squamosus	Curculionidae	Adults eat leaves
Ochyromera artocarpi	Curculionidae	Larvae bore into bud
Phryneta spinator	Lamiidae	Feed under bark
Colopterus posticus	Nitidulidae	-
Trachyostus schaufussi	Platypodidae	--
DIPTERA		
Dacus dorsalis	Tephritidae	Larvae spoil fruit
Dacus umbrosus	Tephritidae	Larvae spoil fruit
HOMOPTERA		
Pealius schimae	Aleyrodidae	Suck sap
Greenidea artocarpi	Aphiddie	Suck sap
Cosmocarta relata	Cercopidae	Suck sap
Ceroplastes rubens	Coccidae	Suck sap
Chloropulvinaria psidii	Coccidae	Suck sap
Nipaecoccus vastator	Coccidae	Suck sap
Stictococcus dimorphus	Coccidae	Suck sap
Stictococcus diversista	Coccidae	Suck sap
Aonidiella aurantii	Coccidae	Suck sap
Hemiberlesia lantaniae	Diaspidae	Suck sap
Icerya seychellarum	Diaspidae	Suck sap
Ferrisia virgata	Margarodidae	Suck sap
Pseudococcus spp	Pseudococcidae	Suck sap
Rastrococcus invadens	Pseudococcidae	Suck sap
HYMENOPTERA		
Oecophylla stnaragdina	Formicidae	Attack workers
LEPIDOPTERA		
Thosea sinensis	Limacodidae	Defoliators
Perina nuda	Lyman triidae	Defoliators
Indarbela tetraonis	Metarbelidae	Larvae are borers
Diaphania bivitralis	Pyralidae	Web leaves
Diaphania caesalis	Pyralidae	Larvae bore shoots

Cajanus cajan

Insect species	Family	Injury
ACARINA		
Aceria cajani	Eriophyidae	Transmit sterility mosaic
Schizotetranychus cajani	Tetranychidae	Infest leaves
Tetranychus spp	Tetranychidae	Infest leaves
COLEOPTERA		
Apion benignum	Apionidae	Larvae damage green seeds,
Apion clavipes	Apionidae	adults chew flowers
Apion ripicola	Apionidae	Larvae damage green seeds,
Apion ugandanum	Apionidae	adults chew flowers
Acanthoscelides cajani	Bruchidae	Destroy seeds
Bruchidius incamatus	Bruchidae	Destroy seeds
Callosobruchus analis	Bruchidae	Destroy seeds
Callosobruchus chinensis	Bruchidae	Destroy seeds
Callosobruchus maculatus	Bruchidae	Destroy seeds
Sphenoptera indica	Buprestidae	Larvae runnel stems
Sphenoptera perotetti	Buprestidae	Larvae tunnel stems
Oxycetonia versicolor	Cetonidae	Feed on leaves
Luperus spp	Chrysomelidae	Feed on leaves
Monolepta spp	Chrysomelidae	Feed on leaves
Podagrica spp	Chrysomelidae	Feed on leaves
Cheilomenes spp	Coccinellidae	Feed on leaves
Epilachna spp	Coccinellidae	Feed on leaves
Alcidodes collaris	Curculionidae	Girdle stems of young plants
Alcidodes fabricii	Curculionidae	Attack seedlings
Atactogaster finitimus	Curculionidae	Larvae destroy buds, damage foliage
Ceutorhynchus asperulus	Curculionidae	Larvae destroy buds, damage foliage
Eucolobes sp	Curculionidae	Larvae destroy buds
Gyponychus Cjuinquemaculatus	Curculionidae	Feed on leaves
Indozocladius asperulus	Curculionidae	Feed on leaves
Myllocerus spp	Curculionidae	Feed on leaves
Nematocerus spp	Curculionidae	Feed on leaves
Phyllobius spp	Curculionidae	Feed on leaves
Systates spp	Curculionidae	-
Euryope sauberlichi	Eumolpidae	-
Aulacophora fouvecollis	Galerucidae	Damage foliage
Prosmidia conifera	Galerucidae	Damage foliage
Ceroplesis signata	Lamiidae	-
Coptops aedificator	Lamiidae	""
Sophronica cinerascens	Lamiidae	-
Tragocephala variegata	Lamiidae	-
Coryna ambigua	Meloidae	Adults feed on pollen
Coryna apicicornis	Meloidae	Adults feed on pollen
Mylabris amplectens	Meloidae	Adults feed on flowers
Mylabris aperta	Meloidae	Adults feed on flowers
Mylabris dicincta	Meloidae	Adults feed on flowers
Mylabris pustulata	Meloidae	Adults feed on flowers
Adoretus spp	Scarabaeidae	Adults feed on leaves
Holotrichia spp	Scarabaeidae	Larvae damage roots
Lyprops breviusculus	Tenebrionidae	-
DIPTERA		
Agromyza sp	Agromyzidae	Larvae mine leaves
Melanagromyza cnalcosoma	Agromyzidae	Maggots feed on green seeds

Cajanus cajan (contd)

Insect species	Family	Injury
Melanagromyza obtusa	Agromyzidae	Maggots feed on green seeds
Ophiomyia centrosematis	Agromyzidae	Maggots tunnel stems
Ophiomyia phaseoli	Agromyzidae	Maggots tunnel stems
Rivellia angulata	Platystomatidae	Maggots feed on root nodules
HETEROPTERA		
Anoplocnemis curvipes	Coreidae	Suck sap from green seeds
Anoplocnemis spp	Coreidae	Suck sap from green seeds
Clavigralla gibbosa	Coreidae	Suck sap from green seeds
Clavigralla scutellaris	Coreidae	Suck sap from green seeds
Clavigralla tomentosicollis	Coreidae	Suck sap from green seeds
Riptortus tenuicornis	Coreidae	Suck sap from green seeds
Riptortus sp	Coreidae	Suck sap from green seeds
Adelphocoris apicalis	Miridae	Suck sap from buds, leaves, flowers
Campylomma spp	Miridae	Suck sap from buds, leaves, flowers
Corizidolon sp	Miridae	Suck sap from buds, leaves, flowers
Creontiades pallidus	Miridae	Suck sap from buds, leaves, flowers
Eurystylus spp	Miridae	Suck sap from buds, leaves, flowers
Hyalopeplus sp	Miridae	Suck sap from buds, leaves, flowers
Lygus infirmus	Miridae	Suck sap from buds, leaves, flowers
Lygus nairobiensis	Miridae	Suck sap from buds, leaves, flowers
Lygus vosseleri	Miridae	Suck sap from buds, leaves, flowers
Dolicoris indicus	Pentatomidae	Suck sap from seeds
Nezara viridula	Pentatomidae	Suck sap from seeds
Piezodorus pallescens	Pentatomidae	Suck sap from seeds
Piezodorus sp	Pentatomidae	Suck sap from seeds
HOMOPTERA		
Bemisia tabaci	Aleyrodidae	Transmit virus
Aphis craccivora	Aphididae	Infest young stem, leaves, pods
Aphis fabae	Aphididae	Infest young stem, leaves, pods
Macrosiphum nigrinectaria	Aphididae	Infest young stem, leaves, pods
Macrosiphum sp	Aphididae	Infest young stem, leaves, pods
Ptyelus grossus	Cercopidae	Girdle stems
Empoasca fabae	Cicadellidae	Suck sap from foliage
Empoasca kerri	Cicadellidae	Suck sap from foliage
Empoasca spp	Cicadellidae	
Jacobiasca lybica	Cicadellidae	Suck sap; plants dry
Aspidiotus hederae	Coccidae	Suck sap from leaf, stems
Ceroplastes mimosae	Coccidae	Suck sap from leaf, stems
Ceroplastes ugandae	Coccidae	Suck sap from leaf, stems
Ceroplastes vinsonioides	Coccidae	Suck sap from leaf, stems
Ceroplastodes cajani	Coccidae	Suck sap from leaf, stems
Coccus elongatus	Coccidae	Suck sap from leaf, stems
Coccus sp	Coccidae	Suck sap from leaf, stems
Dysmicoccus brevipes	Coccidae	Devitalize plants
Hemiberlesia lataniae	Coccidae	Devitalize plants
Inglisia conchiprmis	Coccidae	Devitalize plants
Pinnaspis strachani	Coccidae	Devitalize plants
Planococcus kenyae	Coccidae	Devitalize plants
Pulvinaria inopheron	Coccidae	Devitalize plants
Pulvinaria jacksoni	Coccidae	Devitalize plants
Rastrococcus iceryoides	Coccidae	Devitalize plants
Stictococcus dimorphus	Coccidae	Devitalize plants
Stictococcus diversiseta	Coccidae	Devitalize plants
Icerya purchasi	Margarodidae	Devitalize plants

Cajanus cajart (contd)

Insect species	Family	Injury
Anchon nodicomis	Membracidae	Devitalize plants
Otinotus oneratus	Membracidae	Devitalize plants
Oxyrachis tarandus	Membracidae	Devitalize plants
Xiphistes concolor	Membracidae	Devitalize plants
HYMENOPTERA		
Solenopsis germinata	Formicidae	Attack workers
Megachile spp	Megachilidae	Cut leaves
Tanaostigmodes cajaninae	Tanaostigmatidae	Larvae feed on green seed
ISOPTERA		
Microtermes spp	Termitidae	Damage roots
Odontotermes spp	Termitidae	Damage roots
LEPIDOPTERA		
Amsacta spp	Arctiidae	Defoliators
Spilosoma obliaua	Arctiidae	Defoliators
Anarsia ephippias	Gelechiidae	Leaf folders
Aproaerema modicella	Gelechiidae	Leaf folders
Lecithocera palpigera	Gelechiidae	-
Caloptilia soyella	Gracillaridae	Leaf roller
Stomopteryx subsecivella	Gracillaridae	Leaf miner
Hemerophila simulatrax	Geometridae	Defoliators
Prasinocyma pictifimbria	Geometridae	-
Bombycopsis indecora	Lasiocampidae	-
Catochrysops strabo	Lycaenidae	Bore pods
Deudorix antalus	Lycaenidae	Damage pods
Euchrysops malathana	Lycaenidae	Damage pods
Lampides boeticus	Lycaenidae	Damage pods, buds, flowers
Bracharoa cjuadripunctata	Lyman triidae	Defoliator
Dasychira basalis	Lyman triidae	Defoliator
Dasychira georgiana	Lyman triidae	Defoliator
Dasychira mendosa	Lyman triidae	Defoliator
Dasychira plagiata	Lyman triidae	Defoliator
Euproctis dewitzi	Lyman triidae	Defoliator
Euproctis hargreavesi	Lyman triidae	Defoliator
Euproctis producta	Lyman triidae	Defoliator
Euproctis spp	Lyman triidae	Defoliator
Naroma signifera	Lyman triidae	Defoliator
Acanthoplusia orichalcea	Noctuidae	Feed on flowers
Adisura atkinsoni	Noctuidae	Larvae bore into buds, pods
Adisura marginalis	Noctuidae	Larvae bore into buds, pods
Adisura stigmatica	Noctuidae	Larvae bore into buds, pods
Helicoverpa armigera	Noctuidae	Larvae bore into buds, pods
Helicoverpa zea	Noctuidae	Larvae bore into buds, pods
Helicoverpa punctigera	Noctuidae	Larvae bore into buds, pods
Heliothis virescens	Noctuidae	Attack leaves, buds, flowers
Exelastis atomosa	Pterophoridae	Larvae eat pods
Exelastis crepuscularis	Pterophoridae	Larvae bore pods
Sphenarches anisodactylus	Pterophoridae	Web leaves, damage pods and seeds
Ancylostomia stercorea	Pyralidae	Defoliator
Etella zinckenella	Pyralidae	Defoliator
Maruca testulalis	Pyralidae	Larvae feed on leaves
Nudaurelia dione	Saturnidae	Larvae bore pods
Nudaurelia gueinzii	Saturnidae	Larvae roll leaves
Cydia critica	Tortricidae	Larvae web leaves
Cydia ptychora	Tortricidae	Larvae web leaves

Cajanus cajan (contd)

Insect species	Family	Injury
Eucosma critica	Tortricidae	Larvae web leaves
Leguminivora ptychora	Tortricidae	Larvae web leaves
ORTHOPTERA		
Acanthacris ruficomis	Acrididae	Foliage feeder
Catantops erubescens	Acrididae	Foliage feeder
Colemania sphenerioides	Acrididae	Foliage feeder
Cyrtacanthacris tatarica	Acrididae	Foliage feeder
Patanga succincta	Acrididae	Foliage feeder
Phymateus spp	Acrididae	Foliage feeder
Schistocerca gregaria	Acrididae	Foliage feeder
Zonocerus spp	Acrididae	Foliage feeder
THYSANOPTERA		
Megalurothrips usitatus	Thripidae	Cause bud and flower shedding
Megalurothrips sp	Thripidae	Cause bud and flower shedding

Cassia siamea

Insect species	Family	Injury
COLEOFTERA		
Sinoxylon ruficome	Bostrychidae	Feed under bark
Diapromorpha spp	Chrysomelidae	Defoliator
Celosterna scabrator	Lamiidae	Bore stem, branches
Ceroplesis signata	Lamiidae	Bore stem, branches
HETEROFTERA		
Halyomorpha sp	Pentatomidae	Suck sap
HOMOPTERA		
Aspidoproctus bifurcatus	Coccidae	Devitalize plants
Aspidoproctus glaber	Coccidae	Devitalize plants
Aspidoproctus magnicomis	Coccidae	Devitalize plants
Aspidoproctus pertinax	Coccidae	Devitalize plants
Asterolecanium pustulans	Coccidae	Devitalize plants
Libyaspis harvathi	Plataspidae	Devitalize plants
LEPIDOPTERA		
Azygophleps sp	Cossidae	Larvae bore stems
Xyleutes capensis	Cossidae	Larvae bore stems
Catopsilis pomona	Pieridae	Defoliator
Eurema blanda	Pieridae	Defoliator
Eurema hecabe	Pieridae	Defoliator

Cassia spp

Insect species	Family	Injury
COLEOPTERA		
Sennius instabilis	Bruchidae	Damage seeds
Agrilus aedil	Buprestidae	Feed under bark
Chrysobothris curia	Buprestidae	Feed under bark
Straspis speciosa	Buprestidae	Feed under bark
Monoxenus sp	Lamiidae	Bore into branch
Prosopocera lactator	Lamiidae	Bore into branch
Sophronica grisea	Lamiidae	Bore into branch
Sophronica sp	Lamiidae	Bore into branch
Popillia bipunctata	Rutelidae	Feed on decayed wood
Xyleborus aegir	Scolytidae	Stain the sapwood
HETEROPTERA		
Anoplocnemis sp	Coreidae	Suck sap, secrete toxins
Homoeocerus prominulus	Coreidae	Suck sap, secrete toxins
Blissus leucopterus	Lygaeidae	Suck sap, secrete toxins
Lygus vosseleri	Miridae	Suck sap, secrete toxins
Halys dentata	Pentatomideae	Suck sap, secrete toxins
Loxa virescens	Pentatomideae	Suck sap, secrete toxins
Loxa viridis	Pentatomideae	Suck sap, secrete toxins
Pellaea stictica	Pentatomideae	Suck sap, secrete toxins
HOMOPTERA		
Planococcus kenyae	Coccidae	Suck sap, plants may dry up
Saissetia zanzibarensis	Coccidae	Suck sap, plants may dry up
LEPIDOPTERA		
Xylentes capensis	Cossidae	Larvae bore stems
Latoia lepida	Limacodidae	Defoliator
Charaxes castor	Nymphalidae	Defoliator
Catopsilia croeale	Pieridae	Defoliator
Piesmopoda obliquifasciella	Pyralidae	-
Trachylepidia fructicassiella	Pyralidae	-
ORTHOPTERA		
Phaneroptera furcifera		Damage saplings

Casuarina equisetifolia

Insect species	Family	Injury
COLEOFTERA		
Apate monachus	Bostrychidae	Feed on bark, wood
Chrysobothris tranquebarica	Buprestidae	Feed under bark
Polycesta porcata	Buprestidae	Feed under bark
Stenodontes dasystomus	Cerambycidae	Bore stems
Lixus camerunus	Curculionidae	
Myllocerus maculatus	Curculionidae	Feed on leaves
Celostema scabrator	Lamiidae	Bore into wood
HETEROPTERA		
Halys dentata	Pentatomidae	Suck sap
HOMOFTERA		
Clastoptera undulata	Cercopidae	Suck sap
Nipaecoccus sp	Coccidae	Suck sap
Eurybrachys tomentosa	Eurybrachidae	Suck sap
Ricania Jenestrata	Ricaniidae	Suck sap
ISOPTERA		
Microtermes sp	Termitidae	Damage root, trunk
LEPIDOPTERA		
Zeuzera multistrigata	Cossidae	Larvae bore stem
Ascotis sp		Defoliator
Sahyadrassus malabaricus	Hepialidae	Sapling borer
Lymantria spp	Lyman triidae	Defoliator
Heliothis armigera	Noctuidae	Defoliator
Clania sp	Psychidae	Defoliator
Antheraea paphia	Saturnidae	Defoliator
ORTHOPTERA		
Chondracis rosea rosea	Acrididae	Nibble young plants
Eypreponcnemis alacris	Acrididae	Nibble young plants
Brachytrupes achaetinus	Gryllidae	Nibble young plants
Gymnogryllus humeralis	Gryllidae	Nibble young plants

Casuarina spp

Insect species	Family	Injury
COLEOPTERA		
Apate monachus	Bostrychidae	Make holes in wood
Stigmodera suturalis	Buprestidae	Feed under bark
Anoplophora chinensis	Cerambycidae	Bore into stems
Anoplophora macularia	Cerambycidae	Bore into stems
Aristobia approximator	Cerambycidae	Bore into stems
Stromatium barbatum	Cerambycidae	Bore into stems
Stromatium fulvum	Cerambycidae	Bore into stems
Oncideres pustulatus	Cerambycidae	Bore into stems
Rhyparida limbatipennis	Chrysomelidae	Defoliator
Entypotrachelus meyeri	Curculionidae	-
Hipporrhinus tenuegranosus	Curculionidae	
Mordella sydneyana	Mordellidae	
Crossotarsus extemedentatus	Platypodidae	Feed on bark, wood
HOMOPTERA		
Rastrococcus iceryoides	Coccidae	Devitalize plants
HYMENOPTERA		
Bootanelleus sp	Chalcididae	Destroy seeds
ISOPTERA		
Odontotermes montanus	Termitidae	Damage roots, trunk
Odontotermes sp	Termitidae	Damage roots, trunk
LEPIDOPTERA		
Lymantria xylina	Lyman triidae	Defoliator
"Prodenia litura	Noctuidae	Defoliator
Cirinaforda	Saturnidae	Defoliator
ORTHOPTERA		
Aulachus miliaris	Acrididae	Nibble saplings
THYSANOPTERA		
Pseudanapho thrips casuarinae	Thripidae	-

Cedrela odorata

Insect species	Family	Injury
ACARINA		
Tetranychus mexicanus	Tetranychidae	Suck sap
COLEOPTERA		
Bostrychoplites cylindricus	Bostrychidae	Feed under bark
Crossotarsus sp	Platypodidae	Wood feeder
Pagiophleous longiclavis	Platypodidae	Wood feeder
HETEROPTERA		
Lygus apicalis	Miridae	Suck sap
Lygus simonyi	Miridae	Suck sap
Lygus mrens	Miridae	Suck sap
HOMOPTERA		
Africaspis chionaspiformis	Coccidae	Suck sap
LEPIDOPTERA		
Hypsipyla grandella	Pyralidae	Shoot borer
Hypsipyla robusta	Pyralidae	Shoot borer
Macalla thyrsisalis	Pyralidae	

Croton macrostachys

Insect species	Family	Injury
COLEOPTERA		
Lichenophanes jascicularis	Bostrychidae	Feed on bark, wood
Xylionopsis ukerewana	Bostrychidae	Feed on bark, wood
Chrysobothris sp	Buprestidae	Feed on bark, wood
Falsallophyton gardneri	Cerambycidae	Bore stems
Metameces suturalis	Cerambycidae	Bore stems
Oemida gahani	Cerambycidae	Bore stems
Phrynetopsis fuscicomis	Lamiidae	Bore stems
Pseudochariesthes nigroguttata	Lamiidae	Bore stems
Chaetastus montanus	Platypodidae	-
Doliopygus bidentatus	Platypodidae	Feed under bark
Doliopygus conradti	Platypodidae	Bore into wood
Doliopygus unicus	Platypodidae	Bore into wood
Platypus spinulosus	Platypodidae	Bore into wood
Trachyostus aterrimus	Platypodidae	Feed under bark
Trachyostus schaufussi	Platypodidae	Feed under bark
Macrotoma palmata	Prionidae	Feed under bark
Stephanoderes sp	Scolytidae	Feed on bark, stem
Traglostus exomatus	Scolytidae	Feed on bark, stem
Xyleborus aegir	Scolytidae	Stain the sapwood
HETEROPTERA		
Calidea dregii	Pentatomidae	Suck sap, secrete toxins
HOMOPTERA		
Ptyelus grossus	Cercopidae	Devitalize plant
Planococcus kenyae	Coccidae	Suck sap, plants may dry up
Pulvinaria inopheron	Coccidae	Suck sap, plants may dry up
LEPIDOPTERA		
Nudaurelia gueinzii	Saturnidae	Defoliater

Croton megalocarpus

Insect species	Family	Injury
COLEOPTERA		
Allagogus brunneus	Brenthidae	Defoliator
Bolbocephalus sp	Brenthidae	Defoliator
Bolbocranius tricolor	Brenthidae	-
Megactenodes unicolor	Buprestidae	Feed under bark
Calanthemis hauseri	Cerambycidae	Bore into stems
Chlorophorus carinatus	Cerambycidae	Bore into stems
Oemida gahani	Cerambycidae	Bore into stems
Opepharus spectabilis	Lamiidae	Feed on wood
Chaetastus montanus	Platypodidae	Make tunnels in wood
Chaetastus tuberculatus	Platypodidae	Make tunnels in wood
Doliopygus bidentatus	Plarypodidae	Make tunnels in wood
Doliopygus brevis	Plarypodidae	Make tunnels in wood
Doliopygus coelocephalus	Platypodidae	Make tunnels in wood
Doliopygus conradti	Platypodidae	Make tunnels in wood
Doliopygus nairobiensis	Platypodidae	Make tunnels in wood
Doliopygus serratus	Platypodidae	Make tunnels in wood
Periomatus longicollis	Platypodidae	Make tunnels in wood
Periomatus sp	Platypodidae	Make tunnels in wood
Platypus hintzi	Platypodidae	Make tunnels in wood
Platypus impressus	Platypodidae	Make tunnels in wood
Platypus refertus	Platypodidae	Make tunnels in wood
Platypus spinulosus	Platypodidae	Make tunnels in wood
Trachyostus aterrimus	Platypodidae	Make tunnels in wood
Anoeme sp	Prionidae	Bore into wood
Macrotoma Jbveolata	Prionidae	Bore into wood
Macrotoma palmata	Prionidae	Bore into wood
Mallodon downesi	Prionidae	Bore into wood
Dactylipalpus camerunus	Scolytidae	Feed on bark, wood
Metahylesinus oblongus	Scolytidae	Feed on bark, wood
Xyleborus aegir	Scolytidae	Feed on bark, wood
Xyleborus alluaudi	Scolytidae	Stain the sapwood
Xyleborus camphorae	Scolytidae	Stain the sapwood
HOMOPTERA		
Planococcus kenyae	Coccidae	Devitalize plants
ISOPTERA		
Neotermes meruensis	Kalotermitidae	Damage root, trunk
Odontotermes sp	Termitidae	Damage root, trunk
LEPIDOPTERA		
Amyna punctum	Noctuidae	—

Croton spp

Insect species	Family	Injury
COLEOPTERA		
Stegobium paniceum	Bostrychidae	Make holes in wood
Micrapate puberula	Brenthidae	Feed under bark
Bolbocranius tricolor	Brenthidae	Feed on decayed wood
Microtrachelizus copulatus	Brenthidae	Feed on decayed wood
Bruchus crotonae	Bruchidae	Damage seeds
Bruchus podagricus	Bruchidae	Damage seeds
Stromatium barbatum	Cerambycidae	Bore into stems
Tropimerus cyaneus	Cerambycidae	Bore into stems
Tropimerus hovorei	Cerambycidae	Bore into stems
Xystrocera ansorgei	Cerambycidae	Bore into stems
Anthonomus sp	Curculionidae	Adults defoliate
Stenoscelis binodifer	Curculionidae	Adults defoliate
Frea marshalli	Lamiidae	Feed on stem wood
Monochamus variegatus	Lamiidae	Feed on stem wood
Monoxenus turrifer	Lamiidae	Feed on stem wood
Opepharus spectabilis	Lamiidae	Feed on stem wood
Pterolophia sp	Lamiidae	Feed on stem wood
Didimus latipunctus	Passalidae	Bore into the sapwood
Doliopygus brevis	Platypodidae	Feed on stem wood
Doliopygus interpositus	Platypodidae	Feed on stem wood
Platypus atriimus	Platypodidae	Feed on stem wood
Triozastus banghaasi	Platypodidae	Feed on stem wood
Popillia ukambana	Rutelidae	Larvae damage roots
Pseudophloeotribus oblongus	Scolytidae	Feed on bark, wood
Xyleborus eichhoffi	Scolytidae	Feed on bark, wood
Oryzaephilus mercator	Silvaniidae	Feed on wood
HETEROPTERA		
Pseudatomoscelis seriatus	Miridae	Suck sap, secrete toxins
Calidea dregii	Pentatomidae	Suck sap, secrete toxins
Chrysocoris purpureus	Pentatomidae	Suck sap, secrete toxins
Chrysocoris stollii	Pentatomidae	Suck sap, secrete toxins
HOMOPTERA		
Betnisia tabaci	Aleyrodidae	Suck sap
Ferrisia sp	Coccidae	Devitalize plant
Icerya aegyptiaca	Coccidae	Devitalize plant
Icerya nigroareolata	Coccidae	Devitalize plant
Leptdosaphes beckii	Coccidae	Devitalize plant
Lepidosaphes gloverii	Coccidae	Devitalize plant
Pericerya sp	Coccidae	Devitalize plant
Planococcus kenyae	Coccidae	Devitalize plant
Pulvinaria inopheron	Coccidae	Devitalize plant
Saissetia nigra	Coccidae	Devitalize plant
Saissetia somereni	Coccidae	Devitalize plant
Steatococcus caudatus	Coccidae	Devitalize plant
Stictococcus dimorphus	Coccidae	Devitalize plant
Stictococcus diversiseta	Coccidae	Devitalize plant
Kerria lacca	Kerriidae	-
LEPIDOPTERA		
Rhodogastria bubo	Arctiidae	Defoliator
Nudaurelia gueinz	Saturnidae	Defoliator
ORTHOPTERA		
Locusta migratoria	Acrididae	Defoliator
THYSANOPTERA		
Heliothrips sp	Thripidae	–

Cupressus lusitanica

Insect species	FamUy	Injury
COLEOPTERA		
Chrysobothris abyssinica	Buprestidae	Bore into wood
Chrysobothris dorsata	Buprestidae	Bore into wood
Chrysobothris sp	Buprestidae	Bore into wood
Pseudagrilus sp	Buprestidae	Bore into wood
Acalopus sp	Cerambycidae	Bore into stems
Chlorophorus carinatus	Cerambycidae	Bore into stems
Metameces sp	Cerambycidae	Bore into stems
Oemida gahani	Cerambycidae	Bore into stems
Oemida sp	Cerambycidae	Bore into stems
Cossonus sp	Curculionidae	Feed on wood
Nematocerus striolatus	Curculionidae	Defoliator
Niphades granulipennis	Curculionidae	Feed damaged stem
Oreorrhinus aberdarensis	Curculionidae	Defoliator
Stenoscelis podocarpi	Curculionidae	Feed on wood
Megalognatha rufiventre	Galerucidae	Defoliator
Monochamus ruspator	Lamiidae	Bore into wood
Monochamus triangularis	Lamiidae	Bore into wood
Monochamus variegatus	Lamiidae	Bore into wood
Monochamus sp	Lamiidae	Bore into wood
Monoxenus fuliginosus	Lamiidae	Bore into wood
Monoxenus sp	Lamiidae	Bore into wood
Sophronica rufulescens	Lamiidae	Bore into wood
Anoenie sp	Prionidae	Attack the wood
Phloeosinus aubei	Scolytidae	Feed on the bark
Xyleborus aegir	Scolytidae	Stain the sapwood
HOMOPTERA		
Cinara cupressi	Aphididae	Secrete toxin
Stomaphis longirostris	Aphididae	Suck sap
ISOPTERA		
Macrotermes bellicosus	Termitidae	Damage root, trunk
Macrotermes natalensis	Termitidae	Damage root, trunk
Macrotermes sp	Termitidae	Damage root, trunk
Odontotermes montanus	Termitidae	Damage root, trunk
Pseudacanthotermes sp	Termitidae	Damage root, trunk
LEPIDOPTERA		
Euxoa sp	Agrotidae	Defoliator
Polia speyeri	Agrotidae	Defoliator
Spodoptera striturata	Agrotidae	Defoliator
Gonometa podocarpi	Lasiocampidae	Defoliator
Gonometa sp	Lasiocampidae	Defoliator
Schausinna affinis	Lasiocampidae	Defoliator
Nudaurelia gueinzii	Saturniidae	Defoliator
Epichorista galeata	Tortricidae	Defoliator
ORTHOPTERA		
Acrotylus cabaceira	Acrididae	Nibble saplings
Acrotylus patruelis	Acrididae	Nibble saplings
Acrotylus sp	Acrididae	Nibble saplings
Ailopus thalassinus	Acrididae	Nibble saplings
Coryphosima stenopter producta	Acrididae	Nibble saplings
Heteropternis sp	Acrididae	Nibble saplings

Erythrina ahyssinica

	Family	Injury
COLEOPTERA		
Fornasinius fornasinii	Cetoniidae	Adult a defoliator
Genyodonta flavomaculata	Cetoniidae	Adult a defoliator
HETEROPTERA		
Cyclopelta tristis	Pentatomidae	Suck sap
HOMOPTERA		
Afncaspis chionaspiformis	Coccidae	Devitalize plant
Planococcus kenyae	Coccidae	Devitalize plant
Saissetia somereni	Coccidae	Devitalize plant
Centrotus laxatus	Membracidae	Devitalize plant
Libyaspis sp	Plataspidae	Devitalize plant
Plataspis flavosparsa	Plataspidae	Devitalize plant
Plataspis vermicillaris	Plataspidae	Devitalize plant
Trioza erytreae	Psyllidae	Devitalize plant
ISOPTERA		
Amitermes evuntifer	Termitidae	Damage roots, trunk
LEPIDOPTERA		
Diacrisia atridorsia	Arctiidae	Defoliator
Argyrostagma niobe	Lymantriidae	Defoliator
Dasychira georgiana	Lymantriidae	Defoliator
Euproctis hargreavesi	Lymantriidae	Defoliator
Laelia straminea	Lymantriidae	Defoliator
Pteredoa monostida	Lymantriidae	Defoliator
Alenophalera zeariegata	Notodontidae	-
Stauropussa viridipennis	Notodontidae	-
Charaxes castor	Nymphalidae	Defoliator
Aga.th.odes musivalis	Pyralidae	-
Terastia meticulosalis	Pyralidae	-
Bunaea alcinoe	Saturniidae	Defoliator
Urota sinope	Saturniidae	Defoliator
Polyptychus falcatus	Sphingidae	Defoliator

Erythrina spp

Insect species	Family	Injury
ACARINA		
Breuipalpus pseudostriatus	Tenuipalpidae	Devitalize plant
Brevipalpus sp	Tenuipalpidae	Devitalize plant
Oligonychus sp	Tenuipalpidae	Devitalize plant
Tenuipalpus sp	Tenuipalpidae	Devitalize plant
COLEOFTERA		
Specularius intpressithorax	Bruchidae	-
Acanthophorus serraticomis	Cerambycidae	Stem borer
Oemida gahani	Cerambycidae	Stem borer
Remphan sp	Cerambycidae	Stem borer
Pachnoda sinuata	Cetoniidae	Adult a defoliator
Systates crenatipennis	Curculionidae	-
Idactus ellioti	Lamiidae	Feed on wood
Chrysolagria sp	Lamiidae	Feed on wood
Xyleborus alluaudi	Scolytidae	Stain the sapwood
Xyleborus camphorae	Scolytidae	Stain the sapwood
Xyleborus volvulus	Scolytidae	Stain the sapwood
Xyleborus xanthopus	Scolytidae	Stain the sapwood
HOMOPTERA		
Ptyelus flavescens	Cercopidae	Devitalize plants
Africaspis chionaspiformis	Coccidae	Devitalize plants
Ceroplastes vinsonioides	Coccidae	Devitalize plants
Clavaspis herculeana	Coccidae	Devitalize plants
Hemiberlesia lataniae	Coccidae	Devitalize plants
Planococcus kenyae	Coccidae	Devitalize plants
Pulvinaria inopheron	Coccidae	Devitalize plants
Saissetia oleae	Coccidae	Devitalize plants
Saissetia somereni	Coccidae	Devitalize plants
leery a purchasi	Margarodidae	Devitalize plants
Centrotus laxatus	Membracidae	Suck sap
Hoplophorion pertusum	Membracidae	Suck sap
Libyaspis sp	Plataspidae	Devitalize plants
Plataspis sp	Plataspidae	Devitalize plants
LEPIDOPTERA		
Dasychira plagiata	Lymantriidae	Defoliator
Alenophalera variegata	Notodontidae	Defoliator
Charaxes castor	Nymphalidae	Defoliator
Terastia meticulosalis	Pyralidae	Defoliator
Bunaea caffraria	Saturniidae	Defoliator
Nudaurelia dione	Saturniidae	Defoliator
Polyptychus Jhlcatus	Sphingidae	Defoliator

Eucalyptus spp

Insect species	Family	Injury
ACARINA		
Acadicrus sp	Eriophyidae	Suck sap and devitalize plant
Rhombacus sp	Eriophyidae	Suck sap and devitalize plant
Oligonychus ilicis	Tetranychidae	Suck sap and devitalize plant
Tetranychus urticae	Tetranychidae	Suck sap and devitalize plant
COLEOPTERA		
Apate monachus	Bostrychidae	Stem borer
Allogogus brunneus	Brenthidae	Stem borer
Agrilus opulentus	Buprestidae	Bore below bark
Agrilus sexsignatus	Buprestidae	Bore below bark
Chrysobothris tranquebarica	Buprestidae	Bore below bark
Celostema scabrator	Cerambycidae	Stem borer
Dihammus sp	Cerambycidae	Stem borer
Hastertia bougainvillei	Cerambycidae	Stem borer
Phoracantha recurva	Cerambycidae	Stem borer
Phoracantha semipunctata	Cerambycidae	Stem borer
Stromatium barbatum	Cerambycidae	Stem borer
Chrysophtharta bimaculata	Chrysomelidae	Defoliator
Chrysophtharta hectica	Chrysomelidae	Defoliator
Paropsis atomaria	Chrysomelidae	Defoliator
Paropsis charybdis	Chrysomelidae	Defoliator
Paropsis obsoleta	Chrysomelidae	Defoliator
Trachymela sloanei	Chrysomelidae	Defoliator
Trachymela tincticollis	Chrysomelidae	Defoliator
Xanthogaleruca luteola	Chrysomelidae	Defoliator
Gonipterus gibberus	Curculionidae	-
Gonipterus platensis	Curculionidae	Defoliator
Gonipterus scutellatus	Curculionidae	Defoliator
Hypomeces squamosus	Curculionidae	Defoliator
Nematocerus castaneipennis	Curculionidae	Defoliator
Otiorhynchus cribricollis	Curculionidae	Defoliator
OHorhynchus ovalipennis	Curculionidae	Defoliator
Phaenomerus sp	Curculionidae	-
Stasiastes glabratus	Curculionidae	Defoliator
Luperodes nigrosuturalis	Galerucidae	Defoliator
Megalognatha lamaticomis	Galerucidae	Defoliator
Paranaleptes trifasciata	Lamiidae	Feed on wood
Lyctus brunneus	Lyctidae	Feed on wood
Platypus sp	Platypodidae	Feed on wood
Acanthophorus conifis	Prionidae	Feed on wood
Anoplo gnathus	Scarabaeidae	Adult a defoliator
Holotrichia serrata	Scarabaeidae	Adult a defoliator
Lepidiota alticalceus	Scarabaeidae	Adult a defoliator
Leucopholis irrorata	Scarabaeidae	Adult a defoliator
DIPTERA		
Drosophila flavohirta	Drosophilidae	Damage flowers
HETEROPTERA		
Amblypelta cocophaga	Coreidae	Suck sap
Helopeltis bergrothi	Miridae	Suck sap
Atelocera stictica	Pentatomidae	Suck sap
HOMOPTERA		
Ugada limbata	Cicadidae	Suck sap
Ceroplastes sp	Coccidae	Devitalize plant
Chrysomphalus pinnulifer	Coccidae	Devitalize plant

Insect species	Family	Injury
Eriococcus coriaceus	Coccidae	Devitalize plant
Canephora unicolor	Diaspididae	Devitalize plant
Eurymeloides punctata	Eurymelidae	Devitalize plant
Icerya purchasi	Margarodidae	Devitalize plant
Orthezia insignis	Ortheziidae	Devitalize plant
Cardiaspina bilobata	Psyllidae	Devitalize plant
Cardiaspina tetragonae	Psyllidae	Devitalize plant
Cardiaspina tetrodontae	Psyllidae	Devitalize plant
Ctenarytaina eucalypti	Psyllidae	Devitalize plant
Glycaspis spp	Psyllidae	Devitalize plant
Platyobria adustalata	Psyllidae	Devitalize plant
Platyobria bordenensis	Psyllidae	Devitalize plant
Platyobria brevifbliae	Psyllidae	Devitalize plant
Platyobria capitata	Psyllidae	Devitalize plant
Platyobria cultata	Psyllidae	Devitalize plant
Platyobria lewisi	Psyllidae	Devitalize plant
Platyobria maddeni	Psyllidae	Devitalize plant
Platyobria minima	Psyllidae	Devitalize plant
Glycaspis cameloides	Spondyliaspididae	Devitalize plant
Glycaspis constricta	Spondyliaspididae	Devitalize plant
Glycaspis inusitata	Spondyliaspididae	Devitalize plant
Glycaspis mancyana	Spondyliaspididae	Devitalize plant
Glycaspis riguensis	Spondyliaspididae	Devitalize plant
Glycaspis rupicolae	Spondyliaspididae	Devitalize plant
Glycaspis surculina	Spondyliaspididae	Devitalize plant
Glycaspis wallumari	Spondyliaspididae	Devitalize plant
HYMENOPTERA		
Eurytoma sp	Chalcidae	Larvae form galls
Megastigmus sp	Dryophilidae	Destroy flowers
Quadrastichodella eucalypti	Eulophidae	Damage flowers
Perga affinis	Pergidae	-
Perga dorsalis	Pergidae	Damage flowers
Pergagrapta polita	Pergidae	Damage flowers
Phylacteophaga froggatti	Pergidae	Damage flowers
Phylacteophaga sp	Pergidae	Damage flowers
Doratithynnus kateae	Tiphiidae	Damage flowers
Doratithynnus sp	Tiphiidae	Damage flowers
ISOPTERA		
Bifiditermes improbus	Kalotermitidae	Damage roots, trunk
Kalotermes banksiae	Kalotermitidae	Damage roots, trunk
Kalotermes brouni	Kalotermitidae	Damage roots, trunk
Coptotermes acinaciformis	Rhinotermitidae	Damage roots, trunk
Coptotermes lacteus	Rhinotermitidae	Damage roots, trunk
Coptotermes testaceus	Rhinotermitidae	Damage roots, trunk
Anacanthotermes macrocephalus	Termitidae	Damage roots, trunk
Heterotermes ferox	Termitidae	Damage roots, trunk
Macrotermes natalensis	Termitidae	Damage roots, trunk
Microcerotermes minor	Termitidae	Damage roots, trunk
Microcerotermes serratus	Termitidae	Damage roots, trunk
Microternies obesi	Termitidae	Damage roots, trunk
Nasutitermes exitiosus	Termitidae	Damage roots, trunk
Odontotermes anamallensis	Termitidae	Damage roots, trunk
Odontotermes assamensis	Termitidae	Damage roots, trunk
Odontotermes bellahunisensis	Termitidae	Damage roots, trunk
Odontotermes bijbrmis	Termitidae	Damage roots, trunk
Odontotermes brunneus	Termitidae	Damage roots, trunk
Odontotermes feae	Termitidae	Damage roots, trunk
Odontotermes microdentetus	Termitidae	Damage roots, trunk

Insect species	Family	Injury
Odontotermes obesus	Termitidae	Damage roots, trunk
Odontotermes redemanni	Termitidae	Damage roots, trunk
Odontotermes wallonensis	Termitidae	Damage roots, trunk
Porotermes adamsoni	Termitidae	Damage roots, trunk
Trinervitermes biformis	Termitidae	Damage roots, trunk
LEPIDOPTERA		
Euxoa longidentifera	Agrotidae	Defoliator
Anthela varia	Anthelidae	-
Xyleutes spp	Cossidae	Larvae bore stem
Zeuzera pyrina	Cossidae	Larvae bore stem
Apatelodes sericea	Eupterotidae	_
Aids divisari	Geometridae	Defoliator
Ascotis reciprocaria	Geometridae	Defoliator
Ectropis excursaria	Geometridae	Defoliator
Glena unipennaria	Geometridae	Defoliator
Mnesampela spp	Geometridae	Defoliator
Neocleora tulbaghata	Geometridae	Defoliator
Oxydia platypterata	Geometridae	Defoliator
Oxydia vesulia	Geometridae	Defoliator
Sabulodes caberata	Geometridae	Defoliator
Sabulodes exhonorata	Geometridae	Defoliator
Sabulodes glaucularia	Geometridae	Defoliator
Thyrinteina arnobia	Geometridae	Defoliator
Endoclita hosei	Hepialidae	Sapling borer
Sahyadrassus malabaricus	Hepialidae	Sapling borer
Pyrrhopyge pelota	Hesperiidae	-
Perthida glyphopa	Incurvariidae	Defoliator
Gonometa nysa	Lasiocampidae	Defoliator
Lechriolepis nigrivenis	Lasiocampidae	Defoliator
Pachypasa subfascia	Lasiocampidae	Defoliator
Taragarna cuneatum	Lasiocampidae	Defoliator
Trabela vishnou	Lasiocampidae	Defoliator
Doratifera casta	Limacodidae	Defoliator
Doratifera oxleyi	Limacodidae	Defoliator
Doratifera quadriguttata	Limacodidae	Defoliator
Doratifera vulnarans	Limacodidae	Defoliator
Euproctis molunduana	Lyman triidae	Defoliator
Lymantria ampla	Lyman triidae	Defoliator
Lymantria dispar	Lyman triidae	Defoliator
Desmeocraera varia	Notodontidae	Defoliator
Psorocampa denticulata	Notodontidae	Defoliator
Spilonota sinuosa	Olethreutidae	Defoliator
Pieris rapae	Pieridae	Defoliator
Oiketicus kirbyi	Psychidae	Defoliator
Herculia tenuiia	Pyralidae	-
Athletes ethra	Saturnidae	Defoliator
Lobobunaea phaedusa	Saturnidae	Defoliator
Urota sinope	Saturnidae	Defoliator
Archips micaceanus	Tortricidae	Defoliator
Pelochrista sp	Tortricidae	Defoliator
Strepsicrates macropetana	Tortricidae	Defoliator
Tortrix dinota	Tortricidae	Defoliator
ORTHOPTERA		
Catantops humaralis	Acrididae	Nibble young plants
Cyrtacanthacris tatarica	Acrididae	Nibble young plants
Gymnobothms temporalis	Acrididae	Nibble young plants
Brachytrupes portentotus	Gryllidae	Nibble young plants
Stiphra robusta	Proscopiidae	Nibble young plants

Gliricidia sepium

Insect species	Family	Injury
COLEOPTERA		
Diaprepes abbreviates	Curculionidae	Infest foliage
HETEROPTERA		
Cyclopelta tristis	Pentatomidae	Suck sap
HOMOPTERA		
Aphis craccivora	Aphididae	Suck sap
Toxoptera aurantii	Aphididae	Suck sap
Coccus elongatus	Coccidae	Devitalize plant
Inglisia conchiformis	Coccidae	Devitalize plant
Planococcus kenyae	Coccidae	Devitalize plant
Saissetia Zanzibarensis	Coccidae	Devitalize plant
LEPIDOPTERA		
Sahyadrassus malabaricus	Hepialidae	Sapling borer
Azeta versicolor	Noctuidae	Defoliator
Eurema blanda silhetana	Pieridae	Defoliator

Grevillea robusta

Insect species	Family	Injury
ACARINA		
Brevipalpus australis	Tenuipalpidae	Infest foliage
Brevipalpus phoenicis	Tenuipalpidae	Infest foliage
Oligonychus binoculatus	Tetranychidae	Infest foliage
Oligonychus coffeae	Tetranychidae	Infest foliage
COLEOPTERA		
Apate indistincta	Bostrychidae	Tunnel the stem
Apate monachus	Bostrychidae	Adults bore stems
Bostrychoplites cylindricus	Bostrychidae	Feed on leaves
Bostrychopsis jesuita	Bostrychidae	-
Bostrychopsis villosula	Bostrychidae	-
Enneadesmus Jbrficula	Bostrychidae	Wood borer
Xylionopsis ukerewana	Bostrychidae	Wood borer
Xylionopsis sp	Bostrychidae	Wood borer
Chlorophorus carinatus	Cerambycidae	Bore into stems
Oemida gahani	Cerambycidae	Bore into stems
Monolepta spp	Chrysomelidae	Defoliator
Doliopygus dubius	Platypodidae	Bore into wood
Doliopygus spatiotus	Platypodidae	Bore into wood
Anoeme sp	Prionidae	Bore into wood
Macrotoma dohertyi	Prionidae	Bore into wood
Scolytoplatypas strohmeyeri	Scolytidae	Feed on bark, wood
Xyleborus aegir	Scolytidae	Stain the sapwood
Xyloborus fornicatus	Scolytidae	Stain the sapwood
Xyloborus noxius	Scolytidae	Stain the sapwood
Xylosandrus discolor	Scolytidae	Stain the sapwood
HOMOPTERA		
Asterolecanium pustulans	Asterolecaniidae	Devitalize plant
Aspidoproctus armatus	Coccidae	Devitalize plant
Chrysomphalus pinnulifer	Coccidae	Devitalize plant
Coccus hesperidum	Coccidae	Devitalize plant
Ferrisiana virgata	Coccidae	Devitalize plant
Hemiberlesia lataniae	Coccidae	Devitalize plant
Hemiberlesia rapax	Coccidae	Devitalize plant
Howardia biclavis	Coccidae	Devitalize plant
leery a seychellarum	Coccidae	Devitalize plant
Monophlebus ficus	Coccidae	Devitalize plant
Pagiophloeus umbricidus	Coccidae	Devitalize plant
Perissopneumon tamarinda	Coccidae	Devitalize plant
Pseudococcus ugandae	Coccidae	Devitalize plant
Metaphaena cruentata	Fulgoridae	Suck sap
Trioza erythrea	Psyllidae	Suck sap
HYMENOPTERA		
Crematogaster sp	Formicidae	-
ISOPTERA		
Heterotermes platycepltalus	Rhinotermitide	Damage root, trunk
Macrotermes bellicosus	Termitidae	Damage root, trunk
Macrotermes subhyalinus	Termitidae	Damage root, trunk
Neotermes greeni	Termitidae	Damage root, trunk
Postelectrotermes tnilitaris	Termitidae	Damage root, trunk

Gliricidrevillea robusta (contd)

Insect species	Family	Injury
LEPIDOPTERA		
Zeuzera coffeae	Cossidae	Stem/branch borer
Anadiasa punctifascia	Lasiocampidae	Foliage feeder
Stauropus alternus	Notodontidae	-
Clavia crameri	Psychidae	Feed on leaves
Homona coffearia	Tortricidae	Defoliator
Ectropis bhurmitra	?	-
Oenochroma vinaria	?	
THYSANOPTERA		
Heliothrips haemmorrhoidalis	Thripidae	Lacerate leaves

Grevillea spp

Insect species	Family	Injury
COLEOPTERA		
Xyloperthodes clavula	Bostrychidae	Feed under the bark
Xylopsocus capucinus	Bostrychidae	Feed under the bark
Xylopsocus sellatus	Bostrychidae	Feed under the bark
Chrybothris sp	Buprestidae	Feed under the bark
Psiloptera albomarginata	Buprestidae	Feed under the bark
Scolytoproctus parinariae	Curculionidae	-
Chaetastus montanus	Platypodidae	Feed on the wood
Doliopygus bidentatus	Platypodidae	Feed on the wood
Doliopygus conradti	Platypodidae	Feed on the wood
Doliopygus ghescjuieri	Platypodidae	Feed on the wood
Doliopygus interruptus	Platypodidae	Feed on the wood
Doliopygus nairobiensis	Platypodidae	Feed on the wood
Triozastus banghaasi	Platypodidae	Feed on the wood
Metahylesinus oblongus	Scolytidae	Feed on bark, wood
Scolytoplatypus sp	Scolytidae	Feed on bark, wood
Xyleborus albizzianus	Scolytidae	Stain the sapwood
Xyleborus alluaudi	Scolytidae	Stain the sapwood
Xyleborus ferrugineus	Scolytidae	Stain the sapwood
ISOFTERA		
Odontotermes badius	Termitidae	Damage root, trunk
Pseudacanthotermes militaris	Termitidae	Damage root, trunk

Leucaena leucocephala

Insect species	Family	Injury
COLEOPTERA		
Araecerus fasciculatus	Anthribidae	Feed on seeds
Heterobostrychus aequalis	Bostrychidae	-
Acanthoscelides macrophythalmus	Bruchidae	Feed on green seeds
Cathartus auadricollis	Bruchidae	?
Sphenoptera indica	Buprestidae	Nibble leaves
Oncideres pustulatus	Cerambycidae	?
Oncideres rhodosticta	Cerambycidae	Girdle tissues
Aetheodactyla plagiata minor	Chrysomelidae	Nibble leaves
Colasposoma asperatum	Chrysomelidae	Defoliator
Captocephala minuta	Chrysomelidae	Nibble leaves
Diapromorpha turcica	Chrysomelidae	Nibble leaves
Dereodus pollinosus	Curculionidae	Nibble leaves
Myllocerus cardoni	Curculionidae	Nibble leaves
Myllocerus discolor	Curculionidae	Defoliator
Myllocerus maculosus	Curculionidae	Defoliator
Myllocerus viridanus	Curculionidae	Defoliator
Adoretus sinicus	Scarabaeidae	Defoliator
Adoretus sp	Scarabaeidae	Damage flowers
Anomala sp	Scarabaeidae	Defoliator
Apogonia rouca	Scarabaeidae	Twig borer
Aserica sp	Scarabaeidae	Twig borer
Holotrichia sp	Scarabaeidae	Defoliator
Xylosandrus compactus	Scolytidae	Feed on stemwood
Xylosandrus morigerus	Scolytidae	Feed on stemwood
HETEROPTERA		
Homeocerus signatus	Coreidae	Sap sucker
Chrysocoris purpureus	Pentatomidae	Sap sucker
Nezara graminea	Pentatomidae	Sap sucker
HOMOPTERA		
Bemisia porteri	Aleyrodidae	Suck sap
Asterolecanium pustulans	Asterolecaniidae	Devitalize plant
Coccus elongatus	Coccidae	Devitalize plant
Coccus longulus	Coccidae	Devitalize plant
Hemiberlesia implicata	Coccidae	Devitalize plant
Hemiberlesia lataniae	Coccidae	Devitalize plant
Eurybrachys sp	Eurybrachidae	Suck sap
Kerria lacca	Keriidae	Suck sap, devitalize plant
Leptocentrus taurus	Membracidae	Suck sap, devitalize plant
Otionotus oneratus	Membracidae	Suck sap, devitalize plant
Oxyrachis mangiferana	Membracidae	Suck sap, devitalize plant
Oxyrachis tarandus	Membracidae	Suck sap, devitalize plant
Ferrisia virgata	Pseudococcidae	Devitalize plant
Planococcus citri	Pseudococcidae	Devitalize plant
Heteropsylla cubana	Psyllidae	Harvest leaves
HYMENOPTERA		
Zompopos sp	Formicidae	Damage root, trunk
ISOPTERA		
Microtermes mycophagus	Termitidae	Defoliator

Insect species	Family	Injury
LEPIDOPTERA		
Amsacta lactinea	Arctiidae	Feed on florets
Ithome lassula	Cosmopterigida	Bore branch/twig
Cossus sp	Cossidae	Bore branch/twig
Zeuzera coffeae	Cossidae	Defoliator
Semiothisa sp	Geometridae	Defoliator
Streblote siva	Lasiocampidae	Defoliator
Lymantria sp	Lymantriidae	Defoliator
Orgyia postica	Lymantriidae	Defoliator
Ascalenia sp	Momphidae	Attack flowers
Heliothis armigera	Noctuidae	Defoliator
Spatularia mimosae	Tineidae	Infest pods, stems and leaves
ORTHOPTERA		
Orthacris orthacris	Acrididae	Nibble leaves
Schistocerca sp	Acrididae	Nibble leaves
Gryllotalpa africana	Gryllotalpidae	Nibble leaves
Phaneroptera furcifera	Tettigonidae	Nibble leaves
THYSANOPTERA		
Frankliniella Occidentalis	Thripidae	Attack flowers
Retithrips syriacus	Thripidae	Attack flowers

Markhamia platycalyx

Insect species	Family	Injury
COLEOPTERA		
Anisognathus csikii	Brenthidae	Feed on foliage
Oidosoma congoensis	Chrysomelidae	Feed on foliage
Systates hargreavesi	Curculionidae	-
HETEROPTERA		
Mygdonia tuberculosa	Coreidae	Suck sap
Phyllogonia biloba	Coreidae	Suck sap
Lembella maculigera	Tingidae	Suck sap
HOMOPTERA		
Ceroplastes luteolus	Coccidae	Suck sap
Ceroplastes quadrilineatus	Coccidae	Suck sap
Pulvinaria psidii	Coccidae	Suck sap
Saissetia oleae	Coccidae	Suck sap
Saissetia persitnilis	Coccidae	Suck sap
Saissetia somereni	Coccidae	Suck sap
Stictococcus dimorphus	Coccidae	Suck sap
Stictococcus diversiseta	Coccidae	Suck sap
Stictococcus multispinosus	Coccidae	Suck sap
LEPIDOPTERA		
Hyblaea puera	Agrotidae	Defoliator
Lycophotia ablactalis	Agrotidae	Defoliator
Mazuca strigicincta	Agrotidae	Defoliator
Comibaena leucospilata	Geometridae	Defoliator
Latoia viridicosta	Limacodidae	Defoliator
Parasa chapmanni	Limacodidae	Defoliator
Parasa hexatnitobalia	Limacodidae	Defoliator
Parasa urda	Limacodidae	Defoliator
Euproctis molunduana	Lyman triidae	Defoliator
Salagena atridiscata	Metarbelidae	Bark eater, borer
Polygrammodes junctilinealis	Pyralidae	-
Pyrausta fulvilinealis	Pyralidae	-
Zebronia phenice	Pyralidae	-
Poliana natalensis	Sphingidae	Defoliator
Polyptychus contraria	Sphingidae	Defoliator
ORTHOPTERA		
Phymateus viridipes	Acrididae	Nibble plants
Taphronota calliparea	Acrididae	Nibble plants

Sesbania spp

Insect species	Family	Injury
COLEOPTERA		
Mesoplatys ochroptera	Chrysomelidae	Defoliator
Phaedonia areata	Chrysomelidae	Defoliator
Alcidodes bubo	Curculionidae	Girdle the stem
Trichapion lativentre	Curculionidae	-
DIPTERA		
Dacus cucurbitae	Tephritidae	Destroy buds
HETEROPTERA		
Nezara viridula	Pentatomidae	Inject toxins
Thyanta custator	Pentatomidae	Inject toxins
HOMOPTERA		
Afncaspis chionaspiformis	Coccidae	Devitalize plant
Ferrisiana virgata	Coccidae	Devitalize plant
Libyaspis punctata	Plataspidae	Devitalize plant
Libyaspis sp	Plataspidae	Devitalize plant
HYMENOPTERA		
Bruchophagus mellipes	Eurytomidae	-
ISOPTERA		
Psammotermes hybostoma	Termitidae	Damage root, trunk
LEPIDOPTERA		
Diacrisia obliqua	Arctiidae	Defoliator
Azygophleps scalaris	Cossidae	Bore sapwood
Taragama distinguendum	Lasiocampidae	Defoliator
Cosmolyce boeticus	Lycaenidae	Defoliator
Anticarsia gemmatalis	Noctuidae	
Heliothis armigera	Noctuidae	Defoliator
Spodoptera litura	Noctuidae	Defoliator
Argyroploce rhynchias	Olethreutidae	Defoliator
Cryptophlebia praesiliens	Olethreutidae	Defoliator
Cryptophlebia rhynchias	Olethreutidae	Defoliator
Eurema brenda	Pieridae	Defoliator
Eurema hecabe senegalensis	Pieridae	Defoliator
Laspeyresia phaidomorpha	Tortricidae	Defoliator

Appendix 2. INSECTS ASSOCIATED WITH MULTIPURPOSE TREES AND SHRUBS— summary of field observations made during visits to experimental site

Acacia koa

Insect	*Family*	*Order*	*Role*	*Location*
Undetermined	Membracidae	Homoptera	Suck sap	Mashitshi, Burundi

Cajanus cajan

Insect	*Family*	*Order*	*Role*	*Location*
Undetermined	Undetermined	Coleoptera	Predator on undeterm'd cicadellids (a)	Machakos, Kenya
Drosophila sp (b)	Drosophilidae	Diptera	? found with cercopid colony (c) on pigeonpea	Abondo, Cameroor
Undetermined	Aphididae	Homoptera	Suck sap from leaves	Machakos, Kenya
Undetermined	Aphididae	Homoptera	Suck sap from flowers, buds	Machakos, Kenya
Ptyelus grossus (c)	Cercopidae	Homoptera	Suck sap from branches or stems, which dry up	Abondo, Cameroor
Undetermined (a)	Cicadellidae	Homoptera	Suck sap from leaves	Machakos, Kenya
Undetermined	Cicadellidae	Homoptera	Suck sap from leaves	Machakos, Kenya
Coccus longulus	Coccidae	Homoptera	Suck sap from shoots, which dry up	Machakos, Kenya
Aprostocetus sp	Encyrtidae	Hymenoptera	Parasite on *Coccus longulus*	Machakos, Kenya
Cneiloneurus carinatus	Encyrtidae	Hymenoptera	Hyperparasite on *Coccus longulus*	Machakos, Kenya
Metaphycus ? stanleyi	Encyrtidae	Hymenoptera	Parasite on *Coccus longulus*	Machakos, Kenya
Tremblaya minor = Silvestria minor	Encyrtidae	Hymenoptera	Hyperparasitoid on *Coccus longulus*	Machakos, Kenya
? *Ganaspis* sp	Eucoilidae	Hymenoptera	Parasitoid on Diptera (b?)	Abondo, Cameroor
Eupelmus sp	Eupelmidae	Hymenoptera	Parasite on *Coccus longulus*	Machakos, Kenya
Pheidole megacephala	Formicidae	Hymenoptera	Attend coccids	Machakos, Kenya
Undetermined	Noctuidae	Lepidoptera	Larvae feed on seeds	Machakos, Kenya
Megalurothrips sp	Thripidae	Thysanoptera	Infest flowers	Machakos, Kenya

letters in parentheses indicate suspected relationship between species parked with the same letter
? indicates not confirmed or not known

Calliandra calothyrsus

Insect	*Family*	*Order*	*Role*	*Location*
Apion sp	Apionidae	Coleoptera	Feed on leaves	Rubona, Rwanda
Cryptocephalus sp	Cnrysomelidae	Coleoptera	? with aphid colony	Mashitshi, Burundi
Monolepta pauperata	Chrysomelidae	Coleoptera	Feed on leaves	Mashitshi, Burundi
Undetermined	Cnrysomelidae	Coleoptera	Defoliator	Mashitshi, Burundi
Myllocerus sp	Curculionidae	Coleoptera	Defoliator	Mashitshi, Burundi
Diplognatha silicea	Scarabaeidae	Coleoptera	Injure bark, lick sap	Machakos, Kenya Mashitshi, Burundi
Pachnoda aemula	Scarabaeidae	Coleoptera	Defoliator	Rubona, Rwanda
Antestia cincticollis	Pentatomidae	Heteroptera	Suck sap from tender parts	Mashitshi, Burundi
Atelocera sp	Pentatomidae	Heteroptera	Suck sap	Mashitshi, Burundi
Undetermined	Aphididae	Homoptera	Suck sap from leaves, tender shoots	Mashitshi, Burundi
Undetermined	Margarodidae	Homoptera	Suck sap from shoots	Mashitshi, Burundi
Myrmicaria natalensis	Formicidae	Hymenoptera	? damage bark at stem base	Mashitshi, Burundi
Coptotermes sp	Pvhinotermitidae	Isoptera	Collected from base ol: dying plants	Machakos, Kenya
Megalurothrips sp	Thripidae	Thysanoptera	Infest flowers	Mashitshi, Burundi
Thrips sp	Thripidae	Thysanoptera	Infest flowers	Yaounde, Cameroon

Cassia siatnea

Insect	*family*	*Order*	*Role*	*Location*
Xylopsocus sp	Bostrychidae	Coleoptera	Bore holes in the wood	Machakos, Kenya
ISfephus sp	Coccinellidae	Coleoptera	Predator on *Spilococcus* sp	Machakos, Kenya
Leucopis (Leucopelta) sp.nr. *africana*	Chamaemyiidae	Diptera	Predator on *Spilococcus* sp	Machakos, Kenya
Spilococcus sp	Pseudococcidae	Homoptera	Infest leaves, which dry	Machakos, Kenya
Anagyrus nigrescens	Encyrtidae	Hymenoptera	Parasite on *Spilococcus* sp	Machakos, Kenya
Cheuoneurus carinatus	Encyrtidae	Hymenoptera	Parasitoid of *Spilococcus* sp	Machakos, Kenya
Prochiloneurus aegyptiacus	Encyrtidae	Hymenoptera	Hyperpasitoid of *Spilococcus* sp via *Anagyrus* or ch*eiloneurus* sp	Machakos, Kenya
Pseudectroma sp.nr. *signata*	Encyrtidae	Hymenoptera	Primary parasitoid of *Spilococcus* sp	Machakos, Kenya
Aprostocetus sp	Eulopidae	Hymenoptera	Primary or secondary parasitoid of *Spilococcus.*	Machakos, Kenya
Pheidole megacephala	Formicidae	Hymenoptera	Attend *Spilococcus* sp colony	Machakos, Kenya
Pachyneuron sp	Pteromalidae	Hymenoptera	Primary parasite on *Spilococcus* sp	Machakos, Kenya
Coptotermes sp	Rhinotermitidae	Isoptera	Damage roots, shoots	Machakos, Kenya
Odontotermes nolaensis	Termitidae	Isoptera	Damage roots, shoots	Machakos, Kenya

Cassia spectabil is

Insect	*Family*	***Order***	***Role***	***Location***
Undetermined	Adelgidae	Homoptera	Devitalize plants	Machakos, Kenya

Croton machrostachys

Insect	*Family*	*Order*	*Role*	*Location*
Haltica pyritosa	Chrysomelidae	Coleoptera	Skeletonize leaves	Gakuta, Rwanda
Undetermined	Undetermined	Diptera	Form galls on stem	Mashitshi, Burundi
Undetermined	Undetermined	Homoptera	Suck sap	Gakuta, Rwanda
Undetermined	Margarodidae	Homoptera	Devitalize plants	Machakos, Kenya

Desmodium distortum

Insect	*Family*	*Order*	*Role*	*Location*
Undetermined	Aphididae	Homoptera	Suck sap	Gakuta, Rwanda

Erythrina abyssinica

Insect	*Family*	*Order*	*Role*	*Location*
Adonia sexareata	Coccinellidae	Coleoptera	Predator on cicadellids (a)	Rwerere, Rwanda
Undetermined (a)	Cicadellidae	Homoptera	Suck sap from leaves	Rwerere, Rwanda
Libyaspis (Plataspis) punctata	Plataspidae	Homoptera	Devitalize plants	Mashitshi, Burundi
Libyaspis sp	Plataspidae	Homoptera	Devitalize plants	Mashitshi, Burundi
Aprostocetus sp	Eulophidae	Homoptera	Form galls in leaves	Rwerere, Rwanda

letters in parentheses indicate f suspected relationship between species parked with the same letter

Flemingia congesta

Insect	*Family*	*Order*	*Role*	*Location*
Monolepta vincta	Chrysomelidae	Coleoptera	Defoliator	Rwerere, Rwanda
Undetermined	Membracidae	Homoptera	Suck sap	Rwerere, Rwanda

Gliricidia sepiutn

Insect	*Family*	*Order*	*Role*	*Location*
Undetermined	Cercopidae	Homoptera	Suck sap	Rubona, Rwanda

Leucaena peniculata

Insect	Family	Order	Role	Location
Exochomus flavipes	Coccinellidae	Coleoptera	?	Mashitshi, Burundi

Markhamia lutea

Insect	*Family*	*Order*	*Role*	*Location*
Undetermined	Coccidae	Homoptera	Devitalize plants	Mashitshi, Burundi

Sesbania sesban

insect	*Family*	*Order*	*Role*	*Location*
Mesoplatys ochroptera	Chrysomelidae	Coleoptera	Defoliator	Maseno, Kenya
Undetermined	Chrysomelidae	Coleoptera	Defoliator	Butare, Rwanda
Cheilomenes lunata	Coccinellidae	Coleoptera	?	Rwerere, Rwanda
Chilocerus calvus	Coccinellidae	Coleoptera	?	Butare, Rwanda
Trochalus sp	Scarabaeidae	Coleoptera	Defoliator	Butare, Rwanda
Riptorus sp	Coreidae	Heteroptera	Suck sap	Butare, Rwanda
Cyolopelta tristis	Pentatomidae	Heteroptera	Suck sap	Butare, Rwanda
Undetermined	Cicadellidae	Homoptera	Suck sap, discolour leaves	Rwerere, Rwanda

Spathodea sp

Insect	*Family*	*Order*	*Role*	*Location*
Orseolia sp	Cecidomyiidae	Diptera	Form galls in leaves	Nairobi, Kenya

Warburgia ugandensis

Insect	*Family*	*Order*	*Role*	*Location*
Unidentified (a)	Unidentified	Homoptera	Colonize underside of leaves	Nairobi, Kenya
Undetermined	Eulopidae	Hymenoptera	? found with (a) colony	Nairobi, Kenya

letters in parentheses indicate suspected relationship between species parked with the same letter