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INSECT PESTS OF FOREST TREE SEEDS: THEIR ECONOMIC IMPACT AND CONTROL MEASURES

N. Kulkarni & K.C. Joshi

Forest Entomology Division, Tropical Forest Research Institute, Jabalpur - 482 021, India

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KULKARNI, N. & JOSHI, K.C. 1998. Insect pests of forest tree seeds: their economic impact and control measures. The quality of seed production and seed viability are affected by insect infestations on tree stands and during storage. Infestation causes considerable economic losses. The major group of insect pests damaging flowers, fruits and seeds of various hosts in India and abroad are given in the present paper. Possible management practices are also discussed.

Key words: Seed insect pests - biological control - macro-organisms - pathogens - *Bacillus thuringiensis* - natural enemies

KULKARNI, N. & JOSHI, K.C. 1998. Serangga perosak biji benih pokok hutan: kesan ekonomi dan cara mengawalnya. Mutu pengeluaran biji benih dan keupayaan biji benih dipengaruhi oleh pengerumunan serangga pada dirian pokok dan juga semasa penyimpanan. Pengerumunan ini menyebabkan kerugian dari segi ekonomi. Kumpulan serangga perosak daripada beberapa perumah yang paling banyak memusnahkan bunga, buah dan biji benih di India dan di luar negara telah dinyatakan dalam kertas kerja baru-baru ini. Amalan pengurusan yang perlu juga turut dibincangkan.

Introduction

The problem of seed destruction is increasing due to our increasing reliance on seed sources for the production of seedlings or for trees of known genetic characteristics in reforestation and reclamation programmes. In southern United States alone, trees are cultivated as seed sources over relatively large areas of about 10 000 acres (Goyer & Nachod 1976). The flowers, fruits, seeds and cones, being rich food sources, are vulnerable to insect pests and diseases. Insects that feed on them often cause seed crop failure (Barbosa & Wagner 1989) and thus, exert an adverse impact on natural and artificial reforestation. Regeneration failure, especially in teak (*Tectona grandis*) and sal (*Shorea robusta*) in India and conifers in other countries can be attributed to two factors, firstly, the heavy insect attack in the natural stands at the time of inflorescence and seed formation, and secondly, insect attack on the ground after seed shedding (Chatterjee & Thapa 1970, Khatua & Chakrabarti 1990).

Although there are many reports on forest seed pests of broad-leaved and coniferous tree species (Beeson 1941, Pruthi & Singh 1950, Johnson & Heikkenen 1958, Mathur *et al.* 1958, Johnson 1963, Johnson & Hedlin 1967, DeBarr & Kormanik 1975, Singh & Bhandari 1987, 1988, Joshi *et al.* 1990, Pathak *et al.* 1995), the identification of new pests, reviewing the losses caused by them and their management practices need to be undertaken from time to time.

Insect pests of fruit/cone/seeds

The insect orders, associated with most of the destruction of cones and seeds are Coleoptera (beetles and weevils), Lepidoptera, mainly the families Pyralidae (cone worms), Tortricidae (seed worms), Olethreutidae (cone moths and cone borers), Hymenoptera, primarily the seed chalcids (Torymidae), Hemiptera and Diptera (Cecidomyiidae). The damage caused by insect pests can be categorised into seed damage in standing trees and damage in storage conditions (Singh & Bhandari 1986). A list of some major insect pests damaging flowers, fruits, cones and seeds of conifers, broad-leaved (leguminous and non-leguminous) hosts in India (Beeson 1941, Mathur *et al.* 1958, Singh & Bhandari 1987, 1988) and other countries (Johnson & Heikkenen 1958, Johnsen & Hedlin 1967, DeBarr & Kormanik 1975, Goyer & Nachod 1976) is given in Table 1.

Mathur *et al.* (1958) has listed 558 insect pests damaging flowers, seeds and fruits on 363 plant species in India. The Lepidoptera have the greatest species richness among the cone/seed pests (Mathur *et al.* 1958, Turgeon *et al.* 1994). The cone worms of the genus *Dioryctria* (Pyralidae) are major seed pests of *Cedrus deodara*, firs, pines in India and abroad (Singh & Bhandari 1986). Hedlin *et al.* (1980) described 21 species from the United States, Canada and Mexico. Cone worms begin feeding in the cones only when they are matured larvae. Consequently, a distinct larval entrance hole, often surrounded by silk, is visible on attacked cones. The larvae pupate in a pupation chamber in cones and leave the cavity after adult emergence, resulting in cone mortality and complete seed loss. Similar reports are available on *Cedrus deodara* and chilgoza pines (*Pinus girardiana*) in India (Singh & Bhandari 1986) which are of great commercial importance.

Cone moths of the genus *Barbara* (Tortricidae) are also major seed and cone insects. Among them, *Barbara colfaxiana* Kear. is a particularly important pest of Douglas fir. Seed worms like *Cydia* spp. (*Laspeyresia* spp.) feed almost exclusively on seeds (Coulson & Witter 1984).

The coleopteran seed pests are limited to four families - Scolytidae (cone beetles), Curculionidae (cone weevils), Bruchidae and Cerambycidae. Damage caused by *Conophthorus* species can be substantial in commercially valuable pine species. Successful colonisation of the second-year cones ensures the death of the cones and thus, the loss of all seeds. Infested cones can be easily recognised by resin accumulation at the entrance hole, and discoloured and reduced size of cones. Out of 11 species of *Conophthorus* that occur in North America, 3 are frequently serious pests, i.e. the white pine cone beetle, *C. coriperday* (Schwarz.),

the red pine cone beetle, *C. resinosae* (Hopkins), and the red and ponderosa pine cone beetle, *C. ponderosae* (Hopkins) (Coulson & Witter 1984). In most of the cone beetles, and particularly among the genus *Conopthorus*, adults after leaving their overwintering hybernacula, go through a sequence of behaviours leading to brood establishments, which include initial penetration, construction, and filling up of egg pockets and the plugging of the axial tunnel. The entrance tunnel into the cone is constructed by females which prepare blind egg pockets after reaching the center of the axis. In *C. ponderosae*, on ponderosa pine the female usually girdles the axis near the base, thereby severing the conductive tissues and causing early cone death. Girdling appears to be a prerequisite for brood development (Kinzer 1976).

Cone weevils, though, may not be of great economic importance, yet do cause substantial damage to deciduous tree species. *Curculio* and *Conotrachelus* spp. breed in the acorns of a large number of oak, butternuts, walnuts, hickories and filberts (Barbosa & Wagner 1989). The *Quercus* seed weevil, *Sitophilus glandium* (Marshall) (Curculionidae), attacks young developing acorns of *Quercus semicarpifolia, Q. glauca, Q. lanuginosa* and *Q. leucotrichopora*. The young grubs of this weevil mine throughout the tissues, but older grubs work at the base, leaving the distal part untouched. Sometimes the whole crop is destroyed resulting in poor regeneration of oaks (Singh & Bhandari 1986). The Cerambycids, on the other hand, lay eggs singly between scales of fully grown green cones. The young grubs bore into cones, feed on all tissues including seed and cause damage up to 40%. They are known to cause comparatively lesser damage than other insect orders.

Bruchids are very serious pests of seeds, especially of *Acacia* (Southgate 1983, Dwivedi 1993) and *Albizia* spp. (Mathur *et al.* 1958, Joshi *et al.* 1990) in storage as well as to pods on trees. In India, eight species of bruchids, viz. *Bruchidius pisorum* (Linn.), *B. pygoquadrimaculatus* sp., *B. saundersi* (Jakel.), *B. schrodei, B. uberatus* (Fahr.), *Bruchus bilineatopygus* (Pic.), *B. sparsemaculatus* (Pic.) and *Caryedon gonagra* (Fabr.), have been reported to damage *Albizia* seeds (Singh *et al.* 1983, Singh & Bhandari 1986, Joshi *et al.* 1990). Out of these, *B. bilineatopygus* causes about 80% damage to the seeds of *A. lebbek* and *A. procera* (Joshi *et al.* 1990, Joshi 1992). Light brown coloured, small, active, about 4.0 - 4.5 mm long weevils of *B. bilineatopygus* lay oval, light-yellowish eggs on the young pods of *A. lebbek*, in the first week of September. The small grubs enter the fleshy pods by the middle of September, evidently visible by the oozing of a small quantity of gummy fluid from bored pod. The grubs reach the young seeds by the end of the month where they feed on them and reach to a maximum length of about 5 mm inside the seeds. These grubs are greenish-yellow in colour. They turn into about 4 mm long yellow-coloured pupae by the end of October. These weevils after emerging from the seed pods again oviposit the eggs of the second generation on either side of the seed pods of *A. lebbek* and *A. procera*. These eggs hatch to grubs, which enter inside the seeds to develop into pupae and then ultimately to weevils. These weevils after emerging from the seeds again oviposit eggs on the stored seeds in which they continue to breed. The pest has more than five generations in a year (Joshi 1992).

Lamprey *et al.* (1974) observed *Bruchidius spadicous* Fabr. to be infesting seeds of *Acacia tortilis* × *spirocarpa* in Tanzania. It is said that passage of seeds through the gut of browsing mammals kills the larval insect and renders the seeds viable with higher germination rate (Lamprey *et al.* 1974, Miller & Coe 1993, Miller 1994, 1995).

Seed chalcids (Hymenoptera: Torymidae) are small wasps with long ovipositors well adapted for inserting eggs through pine scales and seeds directly. The larva hatches from a single egg laid inside the seed, feeds entirely within the seed until the adult emerges in the following season. The only external evidence of attack is the adult emergence and exit hole, which can only be detected by X-raying seeds (Coulson & Witter 1984, Barbosa & Wagner 1989). These are represented by single genus *Megastigmus*. The only report of seed chalcid damage from India is *Megastigmus cupressi* (Mathur) (Hymenoptera: Torymidae) on seeds of *Cupressus torulosa* in western Himalaya (Mathur *et al.* 1958).

Seed midges (Cecidomyiidae) are also important seed pests which induce gall formation around seeds, or sometimes fuse with the seed coats, resulting in destruction and failure of seed detachment during seed fall or extraction (Johnson 1963). An average of 14% of seeds are damaged out of 99% of galled seeds which remain in the cone during processing.

Despite their potential injury to seed crops, thrips have escaped attention mainly because of their small size (1.16 mm) and the typical adult behaviour of hiding under bud scales or crevices. Infestation usually occurs in the early stages of flower development in the upper crown causing the flowers to dry and drop. Almost half of the observed flowers on heavily infested slash pine have been reported to be killed by thrips (DeBarr 1969).

Hemipteran insects also cause considerable damage to seeds by sucking sap from pods, fruits and seeds. In India, very few sap-sucking insects damaging pods and seeds are known (Mathur *et al.* 1958, Singh & Bhandari 1986). Among them, *Dysdercus singulatus* F. (Hemiptera: Pyrrhocoridae) is an important pest of green fruits of *Bombax ceiba* (semule) (Browne 1968). Singh and Bhandari (1988) have reported an epidemic swarm of another bug, *Ochrophara montana* Dist. (Hemiptera: Pentatomidae), from Chandrapur (Maharashtra, India) damaging flowers of *Dendrocalamus strictus* on a large scale during 1982-1983. In North America, *Prosopis glandulosa* is known to be attacked by the leaf footed bug *Mozena obtusa* (Uhler) (Hemiptera: Coreidae) (Ueckert 1973).

Economic impact of seed pests

A large portion of annual seed production is destroyed by seed and cone insects (Beeson 1941, Browne 1968, Singh & Bhandari 1986, Barbosa & Wagner 1989, Coulson & Witter 1984). Goyer and Nachod (1976) found that 75% of damage in loblolly pine cones could be attributed to insect pests and only 8-15 % to non-insect pests. *Dioryctria auranticella* (Grote) (Pyralidae) has been reported to cause 39-81% cone mortality and *Megastigmus albifrons* (Hymenoptera: Torymidae) about 46-70% (Elizabeth *et al.* 1989). Unlike many other dendrophagous species, seed insects such as the red pine cone beetle consume a large percentage of their available

food each year (Mattson 1971). A survey study of insects affecting the seeds and cones of ponderosa pine in new Mexico indicates that 5 out of approximately 122 species cause important economic losses by destroying an average of 82% of the usable seed crop (Kinzer 1976). In addition, surviving injured cones may have a low proportion of viable seeds. The damage potential of cone beetles, *Conophthorus* species, is also substantial, as female beetles can attack more than one cone. Annual second year cone mortality has been reported to be 80 % or greater in some circumstances for commercially important tree species such as red pine and ponderosa pine (Kinzer *et al.* 1972, Mattson 1980).

In Chile, *Cryptophlebia carpophagaides* Clarke has been reported to cause 30% loss of *Prosopis tomarugo* seeds (Habit *et al.* 1981). *Mozena abtusa* (Hemiptera: Coreidae) causes 33-89 % damage to *Prosopis glandulosa* (Ueckert 1973). The germination percentage of mesquite seeds attacked by *Chlosochroa ligota* (Say) (Pentatomidae) is reduced to only 0.4% in Texas. This pentatomid bug is reported to suck the juices leaving only dry, non-viable seeds (Smith & Ueckert 1974). In a study conducted in Argentina, 40 out of 145 fruits of *P. flexuosa* and 4 out of 70 incipient fruits of *P. chilensis* reached maturity (Solbring & Centino 1975).

Singh and Bhandari (1986) have reported large scale destruction of chillgoza pine seeds in India at Kalpa, Himachal Pradesh, by *Dioryctria abeitella* (Schiff.) causing up to 50% seed damage. Similarly, seeds of another important species, teak (*Tectona grandis*), are damaged by *Dichocrocis (Conogethus) punctiferalis* (Guenee) (Pyralidae) amounting up to 70% seed destruction in storage. During 1985, the incidence of *Dichocrosis leptalis* (Hamp.) (Pyralidae) on *Shorea robusta* was 3-6 % in Dehra Dun forests in India (Singh & Bhandari 1986). Harsh and Joshi (1993) have reported 70% damage to *Albizia* seeds due to insects and diseases out of which 40 % was due solely to the insects, *Bruchus bilineatopygus* and *B. sparsemaculatus.* Reduced viability and germination failure of these damaged seeds have been reported (Ponnuswamy *et al.* 1990).

Protection of pod/seeds from insect pests

Flower/buds/seed feeding insects can be controlled by spraying insecticides in the field either to individual branches, individual trees or the whole seed production area. In storage, fumigation is useful for controlling infestation by insect pests.

In standing trees

I. Chemical control

Chemical control is the first practical control method developed and is possibly dominant in seed protection. Seed insect control by spraying chemical insecticides has been studied by many workers, i.e. by spraying azinophosmethyl 0.18 %, fenvalrate and permathrin 0.25 %, phophamidon 0.03 %, dimethoate 0.03 %, and monocrotophos 0.04 % against *Dioryctria* spp., *Leptoglossus corculus, Tetyra*

bipunctata, Euzophus cedulla and *Eucosma hypsidrysas* (Van Buijtenen 1981, Nord *et al.* 1984, Singh *et al.* 1988); by spraying gunthion and furadon 10 g against *Euzophera cedrella, Eucosma hyposidra* and *Dioryctria abeitella* (Van Buijtenen 1981); or by drip line application of thimet at 10g/100g against chir pine (*Pinus roxburghii*) seed pests (Tewari 1994a). During the last 30 years, several synthetic insecticides have been tested and registered for use. Of these, azinophosmethyl has been the most commonly and longest used (DeBarr 1990). More recently, the synthetic pyrethroids (Cameron 1989, Valenti *et al.* 1990, Annila & Heliovaara 1991, Nord & DeBarr 1992) and systemic insecticides have been used. The latter are translocated within the tree to the interior of cones and control conophagous and conospermatophagous insects (Valenti *et al.* 1990), but are often not effective in controlling spermatophagous insects (Amirault & Brown 1986). This may be because the amount of insecticide translocated to the seeds is minimal. Systemics are applied to the tree by trunk injection, implantation, foliar application or soil application (Reardon *et al.* 1985, Fogal 1990, Valenti *et al.* 1990). Dimethoate has been used frequently throughout the world (Stein & Tilden 1987, Singh *et al.* 1988, Annila & Heliovaara 1991).

Insects infesting pods of *Acacia nilotica* can be controlled by spraying endosulphan or tetrachlorvinphos (Southgate 1983), orthene or cythion (Felker *et al.* 1981) and malathion (Metcalf *et al.* 1962, Habit *et al.* 1981). The spraying of endosulphan or tetrachlorvinphos (Southgate 1983) or dimecron (phosphamidon) (0.4%) has been suggested against *Laspeyresia perfricata*, a seed pest of *Derris indica* syn. *Pongamia pinnata* (Sushil Kumar 1990).

Systemic granular insecticides, viz. furadon, thimet (phorate), monocrotophos, dimecron and diazinon, are effective against seed boring and sap sucking insects (Singh & Bhandari 1986, Tewari 1994 a,b). Tewari (1994b) suggested foliar spray of 0.25 % water emulsion of Rogor 30 EC or 0.04 % bidrin as effective against *Centarinia dalbergiae* (sisoo gall midges). Spraying of 0.06 % malathion at triweekly intervals has been suggested against fruit flies (Nayar *et al.* 1976) and 0.03 % dimethoate, diazinon or phosphamidon against thrips (Bhutani 1979).

II. Biological control

Recently, progress has been made to identify and develop ecologically safe biorational tactics. For example, mating disruption experiments based on pheromone mediated mating behaviour have been conducted in the southeastern United States since 1980 (DeBarr *et al.* 1984, Grant 1990). The lack of orchard isolation from natural stands usually limit the effectiveness of this tactic (Grant 1990). As an alternative to pheromones, traps that mimic visual cues, either alone or in combination with olfactory cues, have considerable potential for reducing population. Gao *et al.* (1993) demonstrated in Chinese seed orchads that 60 yellow sticky traps per ha captured enough *Strobilomyia* adults to decrease the seed damage. Similarly, clear sticky bands applied around the bole have effectively reduced damage by the flightless weevil *Lepesoma lecontei* (Sexton & Schowalter 1991).

A. Natural enemies (parasites and predators)

Southgate (1983) was first to describe the possibility of using natural enemies of insects for seed pest management in *Acacia* spp. *Trichogramma evanescens* (Hymenoptera: Trychogrammatidae) has been used successfully against *Bambusa tulda* seed borer *Sitotroga cerealella* (Oliv.) (Lepidoptera: Gelechidae). Parasite *Pales townsendi* Bar. (Diptera: Tachinidae) has been effective against *Hyposidra talaca* (Walk.) (Lepidoptera: Geometridae), a sisso seed pest (Tewari 1994b). Parasites attacking bruchids in egg, larval or pupal stages belong to the order Hymenoptera. Among egg parasites, *Uscana semifumipennis* (Hymenoptera: Trichogrammatidae) and several other species of the genus are also associated with Bruchidae. Steffan (1981) suggests that a complex of species are involved in attacking *Bruchus* species, two associated with *Callosobruchus* and one with genus *Bruchidius*, with each one very host specific. Parasitoids of the genus *Bruchobius* are the main species associated with *Bruchidius* on acacia (De Luca 1965, Steffan 1981). *Parasierola* sp. (Hymenoptera: Bethylidae) has been reported to parasitise larvae of *Trachylepidia fructicassiella* (Rag.) (Lepidoptera: Pyralidae). The biology of this parasitoid has been studied by Ahmed and Salarkhan (1986). It appears that no operational seed pest control programme, using natural enemies, has been reported as yet and their use is still at an experimental stage, particularly in India.

B. Micro-organisms (pathogens)

The control of white spruce seeds and cone insects by muscardine fungi *Beauveria bassiana* and *Metarrhizium anisopliae* has been investigated by Timonin *et al.* (1980). These pathogens were more effective against the larvae of *Dasineura canadensis, D.rachiphaga* and *Laspeyresia youngana* (Timonin *et al.* 1980), *Larix* seed pest *Strobilomyia* spp. (Tyul'panova *et al.* 1975) and *Picea* seed pest *Lasiomma anthracina* (Fogal 1986).

Although the microbial insecticide *Bacillus thuringiensis* (Bt.) has been in experimental use in seed orchards since the mid-1970s, it has not replaced chemical insecticides in the operational control programmes; however, it has been registered in the United States for the control of *Dioryctria* sp. (Turgeon *et al.* 1994).

III. Cultural control

The cultural methods like removal of host trees within a radius of several kilometres of an orchard (Roques 1988) and misting of cones with cold water to reduce pollen contamination (Miller 1983) are some methods by which the seed/cone insect pest population may be checked. The removal of colonised seed cones and severely infested host trees is an effective method, particularly in seed orchards. This method effectively reduces the population of *Sinorsillus piliferus*, which overwinters as a nymph in the cones (Han *et al.* 1993). In the United States, burning the infested cones that have fallen to the ground has proven effective for control of *Conopthorus coniperda* (Wade *et al.* 1989).

In storage

Forest seeds can be stored safely by taking some precautions before their final storage, viz. inspection of seeds for their moisture contents, visual examination of cleaning method, scanning through soft X-ray technique, thermotherapy or treatments with chemicals, etc. Fumigation by carbon disulphide is effective for *Bruchus pisorum* L. (Tewari 1994 a, b). Use of ethylene bromide, dichlorvos, and a mixture of carbon disulphide and carbon tetrachloride has been suggested by Ruprez (1978). The application of phosphine (Hole *et al.* 1976) and hydrocyanic acid gas (Southgate 1983) has also been recommended. When storing seeds for longer periods in jute or gunny bags, the bags should be treated with pyrethrine and malathion dusts (Dwivedi 1993).

Besides chemical insecticides, natural botanical products have been tested as seed protectants during storage. A list of some common plants that are recorded as being successfully used to protect stored products has been given by Pandey *et al.* (1976) and Hill (1990). Some plant or plant parts used as crude decoctions have been reported against bruchids, viz. *Azadirachta indica* (kernels), *Capsicum* (pepper chillis), cactus spp. (stem powder), *Annona reticulata* (custard apple seed powder), *Mundulia sericca* (stem bark powder), *Piper nigrum* (black pepper) and *Madhuca latifolia* (stem bark) (Golob & Webley 1980). The rhizome of *Acorus calamus*, drupes of *Thevetia nerifolia* and leaf powders of *Adhotoda vasica* and *Ipomoea cornea* have shown promising prospects of their use (Pandey *et al.* 1976).

Future priorities in seed insect pest management

Identification of new seed insect pests is essential from time to time. In addition, details on their biology and seasonal cycles are required for the application of proper and more environment friendly management practices on tree stands and in storage as well. Work on the losses in terms of economics and viability of seeds caused by insect pests to many important tree species is lacking, and this needs to be carried out. Efforts to utilise alternative natural products, viz. natural enemies and botanical products, to avoid the use of synthetic chemical insecticides have been made, but no successful operational control programme has been reported as yet. Such a control is important, especially in storage, because chemical pesticides sometimes tend to reduce the germination viability, besides giving rise to other environmental implications. Although it is realised that no single alternative control measure can completely replace the use of synthetic chemicals, the operational control practices used in combination with conventional insecticides could be the best solution. This will also follow the concept of Integrated Pest Management and will definitely reduce frequent application of synthetic insecticides.

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References

AHMAD, MUKHTAR & SALARKHAN, A.M. 1986. Biology and behaviour of a parasitoid, *Parasierola* sp. (Hymenoptera: Bethylidae) on *Trachylepidia fructicassialla* Ragnot, a seed borer of *Cassia roxburghii*. *Indian Forester* 112(4): 357 - 365.

AMIRAULT, P.A. & BROWN, N.R. 1986. Cone and seed insects of tamarack, *Larix laricina* (Du Roi) K. Koch, and attempts to control damage using chemical insecticides. *Canadian Entomologist* 118 : 589 - 596.

ANNILA, E. & HELIOVAARA, K. 1991. Chemical control of cone pests in a Norway spruce seed orchard. *Silva Fennica* 25 : 59 - 67.

BARBOSA, P. & WAGNER, M.R. 1989. *Introduction to Forest and Shade Tree Insects.* Academic Press, Inc., New York, London. 638 pp.

BEESON, C.F.C. 1941. *The Ecology and Control of Forest Insects of India and Neighbouring Countries.* Vasant Press, Dehra Dun, India. 1007 pp.

BHUTANI, D.K. 1979. *Insects and Fruits.* International Book Distributors, Dehra Dun, India. 415 pp.

BROWNE, F.G. 1968. *Pests and Diseases of Forest Plantations Trees.* Clarendon Press, Oxford, United Kingdom. 1324 pp.

CAMERON, R.S. 1989. Promising new pesticides for cone and seed insect control in the southern United States. Pp. 193-202 in Miller, G.E. (Ed.) *Proceedings of the Cone and Seed Insect Working Party Conference (IUFRO S2.07-01), 3rd.* Victoria, Canada, 1988. Forestry Canada, Pacific Forestry Centre. 243 pp.

CHATTERJEE, P.N. & THAPA, R.S. 1970. Sal regeneration: the problem of sal seed and seedlings borer, *Pammene theristis* Meyrick in Dehra Dun sal forests. *Indian Forester* 96 : 580 - 586.

COULSON, R.N. & WITTER, J.A. 1984. *Forest Entomology: Ecology and Management.* John Wiley & Sons, New York. 669 pp.

DE LUCA, Y. 1965. Catalogue des metazoaries parasites et predateurs de Bruchidae (Coleoptera). *Journal of Stored Products Research* 1: 51- 98.

DEBARR, G.L. 1969. The damage potential of flower thrips in slash pine seed orchards. *Journal of Forestry* 67: 326 - 327.

DEBARR, G.L. 1990. Research on cone and seed insects in North America, past, present and future. Pp. 1-23 in West, R.S. (Ed.) *Proceedings of the Cone and Seed Pests Workshop. Forestry Canada Information Report* N-X-274. Hull: Forestry Canada.128 pp.

DEBARR, G.L., BERISFORD, C.W. & HANULA, J.L. 1984. Use of sex pheromones for seed and cone insect pest management. Pp. 194-203 in Yates, H.O. III (Ed.) *Proceedings of the Cone and Seed Insects Working Party Conference (IUFRO S2.07-01), 1st.* Athens, 1983. USDA Forest Service, Aschville.

DEBARR, G.L. & KORMANIK, P.P. 1975. Anatomical basis for conelet abortion on *Pinus echinata* following feeding by *Leptoglossus corculus* (Hemiptera: Coreidae). *Canadian Entomologist* 107 : 81- 86.

DWIVEDI, A.P. 1993. *Babul (Acacia nilotica), a Multipurpose Tree of Dry Areas.* M/S Scientific Publishers, Jodhpur, India. 226 pp.

ELIZABETH, A.B., WAGNER, M.B. & KOERBER, T. W. 1989. Relative effect of seed and cone insects on ponderosa pine in Northern Arizona. *Journal of Economic Entomology* 82 : 46.

FELKER, P., CANNAL, G.H. & CLARK, P.R. 1981. Variation in growth among 13 *Prosopis* (mesquite) species. *Experimental Agriculture* 17: 204-218.

FOGAL, W.H. 1986. Applying *Beauveria bassiana* (Bals.) Vuill. to soil for control of the spruce cone maggot *Lasioderma anthracina* (Czerny). Pp. 257-266 in Roques, A. (Ed.) *Proceedings of the Cone and Seed Insects Working Party Conference (IUFRO S2.07-01), 2nd.* Briancon, 1986. INRA, Olivet.

FOGAL, W.H. 1990. White spruce cone crops in relation to seed yield, cone insect damage and seed moth populations. Pp. 76-88 in West, R.S. (Ed.) *Proceedings of the Cone and Seed Pest Workshop.* Forestry Canada Information Report N-X- 274. Hull: Forestry Canada.

GAO, B.Q., YANG, J.L., GENG, H.D. & WU, C.J. 1993. Visual trap catches of *Strobilomyia* spp. (Diptera: Anthomyiidae) in northeastern China. In DeBarr, G.L., Roques, A., Sun, J.H. & Turgeon, J.J. (Eds.) *Proceedings of the Cone and Seed Insects Working Party Conference (IUFRO S2.07-01), 4th.* Beijing and Harbin, 1992. USDA Forest Service, Athens.

GOLOB, P. & WEBLEY, D.J. 1980. *The Use of Plant and Mineral as Traditional Protectants of Stored Products.* Report of the Tropical Products Institute. G. (138). 32 pp.

GOYER, R.A. & NACHOD, L.H. 1976. Loblolly pine conelet, cone and seed losses due to insects and other factors in a Louisiana seed orchard. *Forest Science* 22 : 386 - 391.

GRANT, G.G. 1990. Use of semiochemicals for management of insect pests of coniferous seed orchards. Pp. 47-62 in West, R.S. (Ed.) *Proceedings of the Cone and Seed Pest Workshop.* Forestry Canada Information Report N-X-274. Hull: Forestry Canada.

HABIT, M.A., CONTRERAS, D.T. & GONZALIZ, R.H. 1981. *Prosopis tamarugo : Arbusto Forragero Para Zonas Arides.* Eotudio FAO Production y Protection Vegetal Organization de la Naciones Unidas para la Agricultura y la Alimentation. Roma. 143 pp.

HAN, M.D. , PENG, J.W. & PAN, S.S. 1993. Control of Chinese fir seed bugs in Hunan province. In DeBarr, G.L., Roques, A., Sun, J.H., Turgeon, J.J. (Eds.) *Proceedings of the Cone and Seed Insect Working Party Conference (IUFRO S2.07-01), 4th.* Beijing and Harbin, 1992. USDA Forest Service, Athens.

HARSH, N.S.K. & JOSHI, K.C. 1993. Loss assessment of *Albizia lebbek* seeds due to insects and fungal damage. *Indian Forester* 119 (11): 932 - 935.

HEDLIN, A.F., YATES III, H.O., TOVER, D.C., EBEL, H.H., KOERBER, T.W. & MERKEL, E.P. 1980. *Cone and Seed Insects of North American Conifers.* Canadian Forestry Services, Ottawa; U.S. Forestry Service, Washington; Secr. Agric. Recur. Hidraul, Mexico. 122 pp.

HILL, D.S. 1990. *Pests of Stored Products and their Control.* CBS Publishers and Distributors, New Delhi, India. 217 pp.

HOLE, B.D., BELL, C.H., GOODSHIP, C. & MILLS, K.A. 1976. The toxicity of phosphine to all developmental stages of thirteen species of stored products beetles. *Journal of Stored Products Research* 12 : 135 - 244.

JOHNSON, N.E. 1963. Cone-scale necrosis and seed damage associated with attacks by Douglas-fir cone midges. *Forest Science* 9 : 44 - 51.

JOHNSON, N.E. & HEDLIN, A.F. 1967. *Douglas-Fir Cone Insects and their Control.* Publication No. 1168. Canadian Forestry Branch Department.

JOHNSON, N.E. & HEIKKENEN, H.J. 1958. Damage to the seed of Douglas-fir by the Douglas-fir cone midge. *Forest Science* 4 : 274 - 282.

JOSHI, K.C. 1992. *Handbook of Forest Zoology and Entomology.* Oriental Enterprises, Dehra Dun, India. 383 pp.

JOSHI, K.C., MESHRAM, P.B., USHAKIRAN, K. & RAMBHAJAN, B. 1990. A note on the insect pests of economically important stored forest seeds from north-east and central India and possibilities of their control measures. *Journal of Tropical Forestry* 6(3) : 261 - 263.

KHATUA, A.K. & CHAKRABARTI, S. 1990. Life history and seasonal activity of sal seed weevil, *Sitophilus (Calandra) rugicollis* Casey (Coleoptera: Curculionidae). *Indian Forester* 116 (1) : 63 - 70.

KINZER, H.G. 1976. *Biology and Behaviour of Cone Beetles of Ponderosa Pine and Southwestern White Pine in New Mexico.* New Mexico State University Agricultural Experimental Station Bulletin No. 641.

KINZER, H.G., RIDGILL, B.J. & WATTS, J.G. 1972. *Seed and Cone Insects of Ponderosa Pine.* New Mexico State University Agricultural Experimental Station Bulletin 594.

LAMPREY, H.F., HARLEVY, G. & MAKACHA, S. 1974. Interaction between *Acacia* bruchid beetles and large herbivores. *East African Wildlife Journal* 12 : 81- 85.

MATHUR, R.N., SINGH, BALAWANT & LAL, KISHORI. 1958. *Insect Pests of Flowers, Seeds and Fruits of Forest Trees.* Indian Forest Bulletin No. 223 (Entomology) (New Series). Government of India Press, New Delhi. 105 pp.

MATTSON, W.J. Jr. 1971. Relationship between cone crop size and cone damage by insects in red pine seed production areas. *Canadian Entomologist* 103 : 617 - 621.

MATTSON, W.J. Jr. 1980. Cone resources and the ecology of the red pine cone beetle, *Conophthorus resinosae. Annals of Entomological Society of America* 73 : 390 - 396.

METCALF, C.L., FLINT, W. P. & METCALF, R.L. 1962. *Destructive and Useful Insects.* Fourth edition, McGraw Hill Book Company, New York, San Francisco, Toronto, London. 1087 pp.

MILLER, G.E. 1983. Evaluation of the effectiveness of cold water misting of trees in seed orchards for control of Douglas-fir cone gall midge (Diptera: Cecidomyiidae). *Journal of Economic Entomology* 76 : 916 - 919.

MILLER, M.F. 1994. The costs and benefits of *Acacia* seed consumption by ungulates. *Oikos* 71 (1): 181 - 187.

MILLER, M.F. 1995. *Acacia* seed survival, germination and seedling growth following pod ingestion by large herbivores and seed chewing by rodents. *African Journal of Ecology* 33(3): 194 - 210.

MILLER, M.F. & COE, M. 1993. Is it advantageous for *Acacia* seeds to be eaten by ungulates? *Oikos* 66 : 364 - 368.

NAYAR, K.K. , ANANTHAKRISHNAN, T.N. & DAVID, B. 1976. *General and Applied Entomology.* Tata McGraw-Hill Publications Ltd., New Delhi, India. 58 pp.

NORD, J.C. & DEBARR, G.L. 1992. Persistence of insecticides in a loblolly pine seed orchard for control of the leaf footed pine seed bug, *Leptoglossus corculus* (Say) (Hemiptera: Coreidae). *Canadian Entomologist* 124 : 617 - 629.

NORD, J.C., DEBARR, G.C. & GODBEE, N.A. 1984. High volume application of azinophosmethyl, fenvalrate permethrin and phosmet for control of cone worm (Lepidoptera: Pyralidae) and seed bugs (Hemiptera: Coriedae and Pentatoimidae) in southern pine seed orchards. *Journal of Economic Entomolgy* 77: 1589 - 1590.

PANDEY, M.D., SINGH, S.R. & TIWARI, G.C. 1976. Use of some plant powders, oil extracts as protectants against pulse beetle, *Callosobruchus chinensis* Linn. *Indian Journal of Entomology* 30 : 110 - 113.

PATHAK, S.C., KULKARNI, N. & MESHRAM, P.B. 1995. Forest insect pest control. Pp. 119 - 130 in *Encyclopedia of Environmental Biology*. Volume 2. Academic Press Inc., New York.

PONNUSWAMY, A.S., SURENDRAN, C. & PARMESHWARAN, S. 1990. Effect of insect damage on seed germination in *Albizia lebbeck. Indian Forester* 116 (6) : 509 - 510.

PRUTHI, H.S. & SINGH, M. 1950. *Pests of Stored Grain and their Control.* Manager of Publication, Govt. of India, New Delhi, India. 88 pp.

REARDON, R.C., BARRETT, J., KOERBER, T.W., STIPE, L.E. & DEWE, J.E. 1985. Implantation and injection of systemics to suppress seed and cone insects in Douglas-fir in montana. *Canadian Entomologist* 117 : 961 - 969.

ROQUES, A. 1988. The large cone fly in the French Alps. Pp. 1-28 in Berryman, A.A. (Ed.) *Dynamics of Forest Insects Populations: Patterns, Causes, Implication.* Plenum Publication, Washington.

RUPREZ, A. 1978. *Problems des Entomologia Forestral in Peru Conspecial Attention Sobre and Al Aloarrodo.* Organisation de las Naciones Unides para la Agriculture y la Alimentation. 51 pp.

SEXTON, J.M. & SCHOWALTER, T. 1991. Physical barrier to reduce damage by *Lepesoma lecontei* (Coleoptera: Curulionidae) to conelets in a Douglas-fir seed orchard in western Oregon. *Journal of Economic Entomology* 84 : 212 - 214.

SINGH, PRATAP & BHANDARI, R.S. 1986. Insect pests of forest tree seeds and their control. Pp. 155-171 in *Proceedings of the National Seminar on Forest Tree Seeds.* Indo-Danish Project on Seed Production and Tree Improvement, Andhra Pradesh Forest Department. January 1986, Hyderabad, India.

SINGH, PRATAP & BHANDARI, R.S. 1987. Insect pests of *Acacia tortilis* in India. *Indian Forester* 113 (11): 729 - 733.

SINGH, PRATAP & BHANDARI, R.S. 1988. Insect pests of bamboos and their control. *Indian Forester* 114(10) : 670 - 683.

SINGH, PRATAP, JOSHI, K.C. & GURUNG, D. 1988. Efficacy of some insecticides against the larvae of khasi pine shoot borer, *Dioryctria castanea* Bradley (Lepidoptera: pyralidae). *Indian Forester* 114 (12): 29 - 34.

SINGH,TARLOK, SINGH, BALBIR & SAINI, M.S. 1983. *Bruchidius pygoquadrimaculatus* sp. nov. on *Albizia* sp. (Coleoptera: Bruchidae). *Entomon* 8(4) : 385 - 387.

SMITH, L.L. & UECKERT, D.N. 1974. Influence of insect on mesquite seed production. *Journal of Range Management* 27: 61 - 65.

SOLBRING, O.T. & CENTINO, R.D. 1974. Reproductive adaptations in *Prosopis* (Leguminoseae: Mimosoidae). *Journal of Arnold Arboretum* 56 : 185 - 210.

SOUTHGATE, B.J. 1983. *Handbook on Seed Insects of Acacia spp.* Food and Agriculture Organisation of the United Nations, Rome. 30 pp.

STEFFAN, T.R. 1981. The parasites of bruchids. Pp. 223-229 in Labeyrie, V.(Ed.) *The Ecology of Bruchids Attacking Legumes (Pulses).* Dr. W. Junk Publishers, The Hague.

STEIN, J.D. & TILDEN, P.E. 1987. Single and double application of fenvalerate and dimethoate for control of Douglas-fir seed and cone insects. *Journal of Economic Entomology* 80 : 1076 - 1078.

SUSHIL, KUMAR. 1990. Insect pests of some socio-economic tree species of tribal areas in Madhya Pradesh and their control. Pp. 53-67 in Trivedi, R.N., Sen Sarma, P.K. & Singh, M.P. (Eds.) *Recent Researches in Ecology, Environment and Pollution.* Volume 5. Today & Tomorrow Printers and Publishers, New Delhi, India.

TEWARI, D.N. 1994a. *A Monograph on Chir Pine (Pinus roxburghii Sarg).* International Book Distributors, Dehra Dun, India. 311 pp.

TEWARI, D.N. 1994b. *A Monograph on Dalberzia sisso Roxb.* International Book distributors, Dehra Dun, India. 316 pp.

TIMONIN, M.I., FOGAL, W.H. & LONUSHANSKI, S.M. 1980. Possibility of using white and green muscardine fungi for control of cone and seed pests. *Canadian Entomologist* 112 : 849 - 854.

TURGEON, J.J., ROQUES, A. & DE GROOT, P. 1994. Insect fauna of coniferous seed cones: diversity, host plant interaction and management. *Annual Review of Entomology* 39 : 179 - 212.

TYUL'PANOVA, V.A., GUKASAYAN, A.B. & TYUL'PANOVA, V.G. 1975. The prospects of utilizing muscardine fungi for controlling pests of larch seeds. *Lesovedenie* 2 : 47 - 52.

UECKERT, D.N. 1973. Effect of leaf footed bug on mesquite reproduction. *Journal of Range Management* 26 : 227- 229.

VALENTI, M.A., ABRAHAMSON, L.P. & MAYNARD, C.A. 1990. Control of white pine cone beetle (Coleoptera: Scolytidae) with carbonfuran granules in a New York State white pine seed orchard. *Journal of Economic Entomology* 83 : 2349 - 51.

VAN BUIJTENEN, J.P. 1981. Insecticides for seed orchards : a case study in applied research. *Southern Journal of Applied Forestry* 5 : 33 - 37.

WADE, D.D., DEBARR, G.L., BARBER, L.R. & MANCHESTER, E. 1989. Prescribed fire – a cost effective control for white pine cone beetle. Pp. 117 - 121 in *Proceedings of the 10th Fire and Forest Meteorological Conference.* Ottawa, Canada.

Table 1. List of some major insect pests and damage to fruits/cones/seeds on standing trees and in storage

Tree species	Insect pest	Damaged parts
(a) **Conifers**		
Cedrus deodara	*Euzophera cedrella* Hamp.	Cones and seeds
Pinus spp.	(Lepidoptera: Pyralidae)	
Picea smithiana		
Abies pindrow	*Dioryctria abeitella* Schiff.	Cones and seeds
	(Lepidoptera: Pyralidae)	Seeds in storage
Cupressus torulosa	*Megastigmus cupressi* Mathur	Seeds
	(Hymenoptera: Torymidae)	
Picea smithiana	*Laspeyresia (Enarmonia) ethelinda* Mey.	Cones and seeds
	(Lepidoptera : Tortricidae)	
	Eucosma hypsidryas Mey.	Buds
	(Lepidoptera: Tortricidae)	
Pinus spp.	*Blastobasis transcripta* Zell.	Cones and seeds
Chir pine	(Lepidoptera: Blastobasidae)	
(*Pinus roxburghii*)		
	Chlorophorus strobilicola Champ.	Cones
	(Coleoptera: Cerambycidae)	
Scot pine	*Dioryctria amatella* Hulst.	Seeds
(*Pinus sylvestris*)	(Lepidoptera: Pyralidae)	
Ponderosa pine	*D. auranticella* Grote	Cones and seeds
(*Pinus ponderosa*)	(Lepidoptera: Pyralidae)	
Khasi pine	*D. castanea*	Male cones
(*Pinus kesiya*)	(Lepidoptera: Pyralidae)	
Loblolly pine	*Leptoglossus occidentalis* Heid.	Cone and seeds
(*Pinus taeda*)	(Lepidoptera: Pyralidae)	
	L. corculus Say.	
(b) **Broad-leaved trees:**		
(i) Leguminous tree species		
Acacia spp.	*Argyroploce (Cryptophelbia) illepida* Butler	Pods and seeds in storage
A. nilotica × *indica*	(Lepidoptera: Tortricidae)	
A. farnesiana (*indica*)		
A. senegal		
	Ascalenia sclerodes Mey.	Flowers
	(Lepidoptera: Cosmopterygidae)	
	Azanus ubaldus Gra.	Flowers
	(Lepidoptera: Lycaenidae)	
	Microthrix omichleuta Mey.	Pods
	(Lepidoptera: Pyralidae)	
	Pyloetis (Spatularia) mimosae Staint	Seeds on trees and in storage
	(Lepidoptera: Lyonetiidae)	

(continued)

Table 1 (continued)

A. caesia	*Nacaduba nora* Felder (Lepidoptera: Lycaenidae)	Flowers
A. catechu	*Bucolarcha geodes* Mey. (Lepidoptera: Gelechiidae)	Pods
A. concinna	*Semiothisa fasciata* F. (Lepidoptera: Geometridae)	Flowers
	Araecerus fasciculatus De Geer (Coleoptera: Anthribidae)	Seeds
	Pachymerus (Caryedon) gonagra Fabr. (Coleoptera: Bruchidae)	Pods and seeds
	Callosobruchus chinensis Linn. (Coleoptera: Bruchidae)	Pods and seeds
	Bruchidius ineratus Fahr. (Coleoptera: Bruchidae)	Pods and seeds
A. tortilis	*Bruchidius spadicous* Fabr. (Coleoptera: Bruchidae)	Seeds
Acacia spp.	*Anoplocnemis curvipes* F. (Hemiptera: Coreidae)	Young pods
	Nemausus spp. (Hemiptera: Coreidae)	Mature pods
Albizia spp.	*Ascalenia thoracista* Mey. (Lepidoptera: Cosmopterygidae)	Flowers
	Stathmopoda basiplectra Mey. (Lepidoptera: Heliodinidae)	Pods and seeds
	Syntarucus plinius F. (Lepidoptera: Lycaenidae)	Flowers buds
	Archips (Cacoecia) micaceanus Walk. (Lepidoptera : Tortricidae)	Seeds in storage
	Bruchidius uberatus Fabr. (Coleoptera: Bruchidae)	Pods and seeds
	Bruchus bilineatopygus Pic. (Coleoptera: Bruchidae)	Pods and seeds
A. lebbeck	*Bruchus sparsemaculatus* Pic. (Coleoptera: Bruchidae)	Pods and seeds
	Caryedon gonagra Fabr. (Coleoptera: Bruchidae)	Pods and seeds in storage

(continued)

Table 1 (continued)

Bauhinia spp.	*Laspeyresia palamedes* Mey. (Lepidoptera: Tortricidae)	Flowers and seeds
	Acrocercops globulifera Mey. (Lepidoptera: Lithocolletidae)	Flowers
B. purpurea	*Cryptophlebia illepida* Butler (Lepidoptera: Tortricidae)	Pods and seeds
B. malabarica and *B. racemosa*	*Caryedon gonagra* F. (Coleoptera: Bruchidae)	Pods and seeds in storage
B. accuminata	*Araecerus fasciculatus* Geer (Coleoptera: Anthribidae)	Pods
Cassia fistula and *C. occidentalis*	*Rhacochlaena cassiae* Munro (Lepidoptera: Trypidae)	Seeds in storage
C. corymbosa	*Brachyacma palpigera* Walk. (Lepidoptera: Gelechiidae)	Pods and seeds
	Pyloetis (Spatularia) mimosae (Lepidoptera: Tineidae)	Pods and seeds in storage
	Pyroderces albilinectia Dev. (Lepidoptera: Cosmopterygidae)	Seeds
C. siamea	*Labdia trichaeola* Mey. (Lepidoptera: Cosmopterygidae)	Pods
C. auriculata	*Laspeyresia malesiana* Mey. (Lepidoptera: Tortricidae)	Pods
C. fistula	*L. daedalota* Mey. (Lepidoptera: Tortricidae)	Flowers
	Salebria paurosema Mey. (Lepidoptera: Pyralidae)	Flowers
	Nephopteryx rhodobasalis Hamp. (Lepidoptera: Pyralidae)	Young pods
	Trachylepidia fructicassiella Rag. (Lepidoptera: Pyralidae)	Young and old pods and seeds in storage
	Archips (Cacoecia) micaceanus Walk. (Lepidoptera: Tortricidae)	Stored seeds
C. auriculata	*Araecerus autoralis* Bohe. (Coleoptera: Anthribidae)	Seeds
C. fistula and *C. javanica*	*Bruchus pisorum* Linn. *B. chinensis* Linn. (Coleoptera: Bruchidae)	Seeds

(continued)

Table 1 (continued)

Dalbergia sissoo	*Archips (Cacoecia) micaceanus* Walk. (Lepidoptera: Tortricidae)	Flowers
	Bruchus pisorum L. (Coleoptera: Bruchidae)	Seeds
	Aspidiotus orientalis News. (Hemiptera: Coccidae)	Pods and seeds
	Catarinia dalbergiae (sissoo gall midges) (Diptera: Itonididae)	Flower buds
Derris indica syn. *Pongamia pinnata*	*Laspeyresia perfricata* Mey. (Lepidoptera: Tortricidae)	Pods and seeds in storage
Prosopis spp., *P. tamarugo*, *P. juliflora* and *P. velutina*	*Cryptophlebia carpophagaides* Clarke (Lepidoptera: Tortricidae)	Pods and seeds
	Apion subornatus, *A. ventricosum* & *Microtychius* spp. (Coleoptera: Curculionidae)	Seeds
	Amblycerus epsilon Kings. *A. prosopis*, *Bruchidius* spp. (Coleoptera : Bruchidae)	Pods and seeds
P. juliflora *P. cineraria*	*Bruchidius uberatus* Fahr. (Coleoptera: Bruchidae)	
Leucaena leucocephala	*Heliothis armigera* Hub. (Lepidoptera: Noctuidae)	Flowers
Leucaena glauca	*Araecerus fasciculatus* De Geer (Coleoptera: Anthribidae)	Pods and seeds
Moringa oleifera	*Noorda moringae* Tams. (Lepidoptera: Pyralidae)	Flower buds
Sesbania grandiflora & *Pithecellobium dulce*	*Cryptophlebia illepida* Butler (Lepidoptera: Tortricidae)	Seeds in storage
(ii) Non-leguminous tree species		
Ailanthus excelsa (Samaras)	*Atteva fabriciella* Swed. (Lepidoptera: Yponomeutidae)	One generation on pods
Azadirachta indica	*Araecerus suturalis* Bohe. (Coleoptera: Anthribidae)	Seed borer in storage
Bamboo spp.	*Sitotroga cerealella* Oliv. (Lepidoptera: Gelechiidae)	Seeds
	Ochrophara montana Dist. (Hemiptera: Pentatomidae)	Seeds

(continued)

Table 1 (continued)

Bombax ceiba (Semul)	*Celama sgulida* Staud. (Lepidoptera : Arctiidae)	Flowers
	Echana plicalis Moore (Lepidoptera: Noctuidae)	Fallen flower
	Dysdercus cingulatus F. (Hemiptera: Pyrrhocoridae)	Green fruits
Casuarina spp.	*Caryedon gonagra* Fab. (Coleoptera: Bruchidae)	Seeds
	Bootanomyia orientalis Mathur & Hussey (Hymenoptera: Torymidae)	Seeds
Juglans regia (Akhrot)	*Alcides porrectirostris* Marsh. (Coleoptera: Curculionidae)	Fruits
	Oryzaephilus mercator F. (Coleoptera: Curculionidae)	Fruits
Melia azadirach	*Araecerus fasciculatus* Geer (Coleoptera: Anthribidae)	Stored seed
Quercus spp. (Oak) *Q. semecarpifolia*	*Eucosma dryocarpa* Mey. (Lepidoptera: Eucosmidae)	Acorns
Q. leucotrichophora	*Laspeyresia disperma* Mey. (Lepidoptera: Tortricidae)	Acorns
	Sitophilus glandium Marsh. (Coleoptera: Curculionidae)	Acorns
	Diacranognathus nebulosus Red. (Coleoptera: Curculionidae)	Acorns
	Cryptorrhynchus quercus Marsh. (Coleoptera: Curculionidae)	Acorns
	Thamnurgides glandis Beeson (Coleoptera: Scolytidae)	Acorns
Santalum album	*Callosobruchus theobromae* Linn. (Coleoptera: Bruchidae)	Seeds
	Tribolium castaneum Linn. (Coleoptera: Tenebrionidae)	Seeds in storage
Shorea robusta (Sal)	*Blastobasis crassifica* Mey. *B. molinda, B. ochromorpha* (Mey.) (Lepidoptera: Blastobasidae)	Seeds
	Brachyacma palpigera Walk. (Lepidoptera: Gelechiidae)	Seeds
	Dichocrocis leptalis Hamp. (Lepidoptera: Pyralidae)	Seeds in storage

(continued)

Table 1 (continued)

	Laspeyresia pulverula Mey. (Lepidoptera: Tortricidae)	Seeds
	Pammene theristis Mey. (Lepidoptera: Tortricidae)	Seeds and young seedlings and seeds in storage
	Sitophilus (Calandra) rugicollis Casey (Coleoptera: Curculionidae)	Seeds in tree stands & in storage
	Diplophyes shoreae Marsh. (Coleoptera: Curculionidae)	Seeds in tree stands & in storage
	Coccotrypes integer Eich. (Coleoptera: Scolytidae)	Seeds
	Mesomorphus striolatus Fair. (Coleptera: Tenebrionidae)	Seeds
	Gonocephalum planatum Walk. (Coleoptera: Tenebrionidae)	Sown seeds
Swietenia mahogoni	*Hypsipyla robusta* Moore (Lepidoptera: Pyralidae)	Seeds in storage
Terminalia bellirica (Bahera)	*Mecobaris terminaliae* Marsh. (Coleoptera: Curculionidae)	Fruits
Terminalia catappa (Badam)	*Araecerus fasciculatus* De Geer (Coleptera: Anthribidae)	Fruits and seeds
Terminalia chebula	*Attagenus alfierii* Pic. & *A. gloriosae* F. (Coleoptera: Dermestidae)	Stored fruits
Terminalia myriocarpa	*A. gloriosae* F. & *A. attagenus* (Coleoptera: Dermestidae)	Fallen fruits
Toona spp.	Meliaceae shoot borer	
Toona ciliata	*Hypsipyla robusta* Moore (Lepidoptera: Pyralidae)	Flowers and fruits
	Archips (Cacoecia) micaceanus Walk. (Lepidoptera: Tortricidae)	Inflorescence, fruits and seeds in storage
Tectona grandis (Teak)	*Pagyda salvalia* Walk. (Lepidoptera: Pyralidae)	Inflorescence, fruits and seeds
	Dichocrosis (Conogethus) punctiferalis Guenee (Lepidoptera: Pyralidae)	Seeds on trees and storage
	Archips (Cacoecia) micaceanus Walk. (Lepidoptera: Tortricidae)	Seeds in storage
	Lasioderma serricorne Fabr. (Coleoptera: Anobiidae)	Seeds in storage