

11 Insect Pests of Bamboos in India

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1. Introduction

Bamboos are one of the important and precious non-woody bioresources, which are used for a variety of purposes. They are liable to be attacked by various kinds of insects (Beeson, 1941; Mathew and Nair, 1988; Mathew and Varma, 1988; Singh and Bhandari, 1988; Tewari, 1988; Paduvil, 2008). These insects can be broadly divided into two categories one which attack live bamboos, and other attacking post-harvested bamboos. In the first category, the major ones include insects which attack seeds, foliage and culms. They belong to insect orders including Orthoptera, Hemiptera, Lepidoptera, Hymenoptera and Coleoptera (Singh and Bhandari, 1988; Haojie *et al.*, 1998; Koshy *et al.*, 2001). The nature of damage includes foliage feeding, sucking the sap and making bore holes on culms and shoots.

The shoot and culm borers cause more damage to bamboo clumps as compared to other groups of insects. Most defoliating insects remain low in population and hence, are generally considered pests of minor importance. But some of them show periodic fluctuations in population which may cause epidemics, and can cause even total defoliation of bamboo stands. Damage caused by leaf feeders reduces the surface area available for photosynthesis, affecting vigour, growth and survival of plants.

A large number of insects, which have highly modified piercing-sucking mouthparts, feed on the sap of leaves, branches, culms, shoots, roots and rhizomes. These insects can damage bamboos in four ways: (1) removing the plant fluid, (2) causing mechanical injury, (3) injecting toxic compounds into the plant, and (4) transmitting diseases, resulting into defoliation, wilting of young shoots and branches, and even death of the culm. Compared to defoliators and sap suckers, culm and shoot borers have less impact on the plant physiology.

The finished products made out of bamboos are also prone to attack by insect borers (Mathew and Nair, 1988). The post-harvest pests are from the order Coleoptera, especially families Bostrychidae, Lyctidae and Anobidae. of these, Bostrychidae are the most prevalent. Nearly 16 species of Bostrychids are reported to attack post-harvest and finished bamboo products. The bamboo industry in many places consider insect pests as a threat in their storage yards and even without any economic assessment, the severity of the problem is well projected. Thakur and Bhandari (1997) reported from a study carried out by Forest Research Institute (FRI), Dehradun in Jaffrabad Forest Depot, that nearly 40 per cent of stored bamboo was damaged severely by borer attack which resulted to almost a loss of 40 million rupees to the forest department. Similar reports from the storage yards and on finished products made out of bamboos have also been reported from Kerala (Paduvil, 2008).

More than 800 insect species have been recorded on bamboos in Asian countries, but their impact on bamboo industry has been recognised only in a few countries. Although, nearly 180 insect species are reported to be associated with bamboos in India, the pest status of many species is not known.

2. Seed Pests

2.1. *Udonga montana* Distant (Hemiptera: Penatomidae)

Udonga montana is a major seed pest with distribution in India, Bangladesh and Myanmar (Fig. 2.1.1.). The bugs feed on the developing seeds on the flowered culm as well as the seeds which have fallen on the ground, thereby, affecting the regeneration process in nature. Eggs are laid in groups on flower heads. The newly hatched nymphs are black in colour and about 2 mm in length. The adults are ochreous yellow. Attack normally occurs during flowering season. Due to gregarious flowering of bamboo which provides an abundant food, the bugs multiply rapidly in enormous number and result in an outbreak situation. They assemble in large number on all kinds of trees to droop and, sometimes, break off. Damage is caused by sucking the juice from the seeds.

2.2. *Sitotroga cerealella* (Grain moth) (Lepidoptera : Gelechiidae)

It is a cosmopolitan pest of stored grains and seeds (Fig. 2.2.1.). It has been recorded from seeds of bamboos, more particularly in *Bambusa burmanica*. There is only one larva in each seed and the insect passes its entire lifecycle feeding inside the seed. The eggs of this species are frequently parasitised by *Trichogramma evanescens* and consequently are, sometimes, employed for mass breeding of the parasitoides in biological control.

3. Nursery Pests

No major pest problems are reported from bamboo nurseries. Damages due to termites, white grubs and grasshoppers are known from several locations in India.

3.1. *Odontotermes* sp. (Isoptera: Macrotermitidae)

Odontotermes microdentatus and *O. obesus* are the two major mound building termites in India. These termites have been observed causing direct injury to the roots of germinating seedlings and rhizomes of *Bambusa tulda* in New Forest, Dehradun nursery. The damage occurs below the ground level. The termites eat away the fibrous roots, leading to drying up of the young seedlings. The damage caused is only of minor nature.

3.2. *Holotrichia consanguinea* Blanchard (Coleoptera: Scarabaeidae)

Heavy attack of chafer grub *H. consanguinea* has been recorded in one year old nursery stock of *Dendrocalamus strictus* in Chhindwara, Madhya Pradesh and from Kerala. The intensity of attack was heavy and nearby 50 per cent seedlings were found killed due to chafer grub attack. The grubs had eaten away the developing rhizomes resulting in the death of the seedlings.

3.3. *Hieroglyphus banian* Fab. (Orthoptera: Acrididae)

The nymphs and adult of this green and light brown polyphagous grasshopper species defoliate the leaves of *D. strictus* from July to September in India and Pakistan. The mature grasshopper lays eggs in soil in September-October which remain unhatched till June. It has one generation in a year. It is minor pest in bamboo nurseries (Fig. 3.3.1.).

3.4. *Poecilocerus pictus* Fab. (The painted grasshopper) (Orthoptera: Pyrgomorphidae)

The nymphs and adults of this conspicuous grasshopper with ornamental lines and stripes of bright bluish green and yellow colour, feed on the foliage of numerous plants including bamboos in drier zones of India and Pakistan (Fig. 3.4.1.). It is a minor pest in bamboo.

4. Defoliators

Bamboos have quite a rich complex of defoliators (48 species) belonging to the order Coleoptera, Lepidoptera and Orthoptera. Of these 80 per cent species cause defoliation in bamboos, more particularly in *D. strictus* and in most cases these are minor pests. However a few species such as *Pyrausta bambucivora*, *P. coclesalis* and *Poecilocerus*

pictus have been reported to cause serious damage to bamboos in many localities in the Indian sub-continent. Defoliators and leaf rollers cause the major damage during rainy season leading to foliage loss.

4.1. *Algedonia (Pyrausta) coclesalis* Walker (Lepidoptera: Pyralidae)

Algedonia coclesalis, also known as greater bamboo leaf roller is the most destructive pest of bamboos (*Arundinaria* sp., *B. vulgaris*, *Dendrocalamus latiflorus*, *Phyllostachys pubescens*, *P. viridis* and *Schistostachyum gracile*) which has cosmopolitan distribution. In addition to India, they are also found in Bangladesh, Cambodia, China, Indonesia, Laos, Korea, Malaysia, Myanmar, Pakistan, Sri Lanka and Vietnam. This defoliator occurs practically at all elevations up to 1,200 m. The affected leaves are found webbed in bunches and gradually wither, turn pale or straw coloured and eventually drop off. Small scale outbreaks occur and cause defoliation in bamboo plantations in northern India, during the rainy season.

The larva rolls the leaf and feeds within, moving on to a new leaf when the old leaf is half eaten. The young larvae feed on the upper leaf tissue and skeletonise numerous small irregular areas in the leaf blades or make small punctures on the leaves. Older caterpillars web together or roll several adjoining leaves with silk and excretal particles. The larvae feed on the inner whorl of the leaves and the space inside is filled with large quantities of yellowish white excreta mixed with silk spun by the larvae. It has three to four generations per year and larval stage included seven to eight instars. Normally the attack of this insect is kept under check by tachinid and ichneumonid parasitoids and carabid and mantid predators.

4.2. *Algedonia (Pyrausta) bambucivora* Moore (Lepidoptera: Pyralidae)

This moth occurs throughout the Indian sub-continent and many other localities of Southeast Asia. The larvae are injurious leaf rollers of *Bambusa nutans*, *B. vulgaris*, *Dendrocalamus strictus*, *D. giganteus*, *S. gracile* and other bamboos in plantations, particularly during July-October. It is commonly referred to as lesser leaf roller. This species is injurious to bamboos in north-west Himalayan region, particularly in nallahs during July October. The smooth, naked, pinkish larvae feed inside the rolled leaves of the host and eventually they pupate in cocoon. The species has four generations in a year. The species is reported to be a serious pest in Punjab.

4.3. *Hieroglyphus banian* Fab. (Orthoptera: Acrididae)

Hieroglyphus banian is a green or brownish grasshopper and is a pest of rice, maize and wild grasses in the Indian sub-continent, especially in swampy lands in sub-

montane areas. It is also frequently injurious to *D. strictus*. A serious epidemic of this species was recorded in Punjab in 1933-45. The adult lay eggs in masses (7-30) either in soil or litter late in the year which do not hatch until monsoon of the following year. Eggs are parasitised by *Scelio hieroglyphii* Timb. (Hymenoptera).

4.4. *Poecilocerus pictus* Fab. (Orthoptera: Acrididae)

Poecilocerus pictus is a conspicuous strikingly coloured grasshopper with ornamented lines and stripes of bright bluish green and yellow colour with its distribution in India and Pakistan. It is a polyphagous species and is chiefly a pest of *Calotropis gigantea* and *C. procera*, but is also known to cause occasionally severe defoliation in bamboo forests in dry regions of India. The main bamboo host recorded is *D. strictus*. The species has an annual life-cycle. The adult female lays eggs in masses in soil, overwintering in the egg stage or occasionally in nymphal stage. It is a minor defoliator but the species is reported to be a serious pest in forest nurseries in Pakistan.

4.5. *Pioneaflavo fimbriata* Moore (Lepidoptera: Pyralidae)

Pioneaflavo fimbriata is a minor defoliator of *D. strictus*. The moths are brown with fuscous wings and actively fly about at dusk and night. The larvae gnaw through the upper tissue of the leaf causing a skeletonised effect on the leaf or eat the leaves from the edges in a ragged manner. The larvae hibernate inside the thick cocoons formed on the leaves from November onwards and the emergence of moth takes place during the end of March of the following year and continues until May. The defoliator is parasitised by *Microgaster kuchingensis*. *P. fimbriata* is not a serious pest, though sporadic epidemic do occur.

4.6. *Calmochrous pentasaris* Meyrick (Lepidoptera: Cosmopterigidae)

The attack by this moth is reported from India (Uttar Pradesh and Punjab) and Bangladesh on *D. strictus*. It is a rare species. The caterpillar binds several leaves together and spins a firm cocoon inside for pupation. While the pre pupal period is about a day, the pupal period occupies seven to eight days in August. The moth is very small with narrow conspicuously fringed wings. The larvae mines the leaves of bamboos, eating away patches of internal tissues, leaving the outer layers of cell intact, turning into yellowish-white on drying. The larvae form large blotch mines on either sides of midrib of the leaves of *D. strictus* and other bamboos. The fully grown larvae may severe the margins of the wide part of the blotch, roll one layer longitudinally inwards, pupating within the rolled tissue. The species is heavily parasitised.

4.7. *Crocidophora ptyophora* Hampson (Lepidoptera: Pyralidae)

Crocidophora ptyophora is a minor defoliator of bamboo species, reported from India (Bihar, Sikkim and Tamil Nadu) and Myanmar (Tenasserim). The larvae roll up green leaves with silk thread and feed on the inner leaves of the shelter so formed. When about to pupate it constructs a thick cocoon of silk mixed with chewed up leaf fibre inside the roll. In Bihar (Pusa) the larvae are found in January and moths appear from March to May. The caterpillars appear to hibernate for about a couple of months inside the cocoon before pupation. The pupal period is of about 10 days in July at Nilambur (Kerala) and 9-13 days in October in Tittimathi (Karnataka). The moth with bright yellow wings have broad purplish marginal band.

4.8. *Bertona funeralis* Bulter (Lepidoptera: Zygaenidae)

Bertona funeralis, distributed in India, China, Japan and Korea is a major defoliator of bamboos (*Arundinaria* sp., *Bambusa* sp., *Phyllostachys* sp. and *Pseudosasa* sp.). The pest prefers dry, hot conditions, and occurs mostly on the edge of stands and on the plants growing with lower culm density on dry and hot slopes. Adult moths are 9-11 mm long and bright dark green in colour. The centre of the hind wings is transparent. Fully grown larvae are 16-19 mm long, brick-red in colour, and have four verrucae arranged transversely on the back of each segment. There are three to five overlapping generations per year with six larval instars, varying with locality, overwintering as fully fed larvae in cocoons. Eggs are laid in single-layer masses on the back surface of leaves in the lower crown. Very young larvae feed in groups on the leaf surface, leaving characteristic white spots, and older ones consume leaves fully.

4.9. *Pantana pluto* Leech (Lepidoptera: Lymantridae)

Pantana pluto is widely distributed in India, China, Indonesia, Myanmar and Vietnam (Fig. 4.9.1.). It is a recorded pest of *P. pubescens*. The moth is 11-16 mm long and light yellow (female) or dark brown (male) in colour. There are five larval instars, and larvae vary in colour from dark brown to yellowish-brown. Adult moths are active at night, with strong phototaxis. Eggs are laid in single rows on leaves, sheaths and culms. Larvae feed on leaves from March to November. The larvae of the second generation occurring in May-July cause most damage. There are three to four generations per year.

4.10. *Parasa bicolor* Walker (Lepidoptera: Eucleidae)

P. bicolor is a minor defoliator of bamboos (*Arundinaria* sp., *Bambusa* sp., *Phyllostachys* sp., *Pleioblastus* sp. and *Sinobambusa* sp.) and is distributed in India, China, Myanmar, Sikkim and Sri Lanka (Fig. 4.10.1.). As the name suggests, the 13-19 mm long adult has green coloured head, thorax and forewings, and brown-coloured

abdomen and hind wings. Fully developed larvae are 26-32 mm long and yellowish green in colour. Adults are active at night, with phototaxis. Eggs are laid in single or double rows on the back surface of leaves and take six to ten days to hatch. There are eight larval instars. Young larvae feed in groups on leaf surface, leaving brownish-white leaf epithelium, but older ones consume all leaf tissue. The fully developed larvae drop to the ground, burrow into the soil and pupate in cocoons at 2-5 cm depth. Larvae occur from April to June, July to August and September to November. The pest overwinters as fully fed larvae in cocoons in the soil. This pest can be managed at a low population by light-trapping during adult stage and soil-turning in winter to kill overwintering larvae on the soil surface.

4.11. *Stenadontaradialis* gaede (Lepidoptera: Notodontidae)

This is a puss moth distributed in India and China. It hosts on the *Phyllostachys* sp. and *D. latiflorus*. There are three to four generations per year. Adults are active at night and show phototaxis. They lay eggs individually on leaves. Larvae feed on leaves during summer and autumn months. These species rarely cause an outbreak but are capable to cause considerable defoliation in isolated areas. Protecting natural enemies, especially the egg parasites, soil-turning in early winter and light-trapping during adult stage are important methods for the suppression of population of these puss moths.

Other puss moths seen in bamboo species are *Noraccaretrofusca* De Joannis, *Noraccadecurrens* Moore and *Niganda strigifascia* Moore. All these species belonging to the family Notodontidae have similar life histories and symptoms of damage.

4.12. *Sylepta derogata* Fabricious (Lepidoptera: Pyralidae)

S. derogata is mainly distributed in India, Bangladesh and Pakistan. The pest is polyphagous and attacks agricultural crops and forest plants apart from various bamboo species. The moth which hosts on the bamboo species is pale yellow in colour. Eggs are laid in rolled leaf cases. The larvae, on hatching, feed gregariously on the rolled leaf. Pupation is in the soil or litter. The life cycle varies from 23 to 45 days, at times prolonged by larval aestivation and hibernation.

4.13. *Massepha absolutalis* Waker (Lepidoptera: Pyralidae)

M. absolutalis is a regular defoliator of *D. strictus*, but not considered a pest of significance (Fig. 4.13.1.). It is distributed in India, Bangladesh and Sri Lanka. The pest is fairly abundant in the monsoon and passes the winter in the larval stage inside a boat-shaped case made of leaves. Moths emerge only in the following spring. The larvae are parasitised by species of *Chelonus* sp., *Brachymeria* sp. and *Tetrastichus* sp.

4.14. Satyr Butterflies (Lepidoptera: Satyridae)

In India, six *Lethe* species are associated with bamboos and are causing moderate damages. *L. drypetistodara* Moore defoliates *Bambusa* spp., and *L. incana* Kollar, *L. verma* Kollar, *L. yama* Moore, etc. defoliate *Drepanostachyum falcatum*. They are mostly active from May to July. Most of the satyr butterflies are primarily pests on rice and are generally less abundant in bamboo stands, although some can cause significant defoliation. The larvae tie leaves to form cases and feed from within.

4.15. *Calaenorrhinus ambareesa* Moore (Lepidoptera: Hespertiidae)

C. ambareesa Moore is recorded as a new pest, feeding on leaves of *B. bambos* from Kerala. The larvae cut and fold small flaps on the bamboo leaves and feed from within. Widespread occurrence of the pest is not observed.

4.16. *Schistocera gregaria* Forskal (Orthoptera: Acrididae)

S. gregaria is a minor defoliator of *D. strictus* in India (Fig. 4.16.1.). An important defoliating pest of agricultural crops in many countries, it is also injurious to young regenerations and sowings in forest plantations in Punjab, Rajasthan and Haryana in India. In the gregarious phase, it feeds on all bamboo species besides other vegetation, while in the solitary phase it feeds on *D. strictus*. Various vertebrates and invertebrates prey upon adults and nymphs. Birds especially kites, crows and starlings are predators of the locust. Larvae of *Troxprocerus* sp. (Coleoptera) has been found to cause 100 per cent destruction of locust eggs sometimes.

5. Sap Sucking Insects

Bamboos seem to be the natural hosts for sap suckers. Large number of insect species belonging chiefly to families Aleyrodidae, Aphididae, Coccidae and Membracidae has been recorded from various species of bamboos. Of about 90 species which have been found associated with bamboos, species of genera *Asterolecanium* (18 species), *Chionaspis* (four species), *Odonaspis* (nine species) and *Oregma bambusae* have been found erupting occasionally to epidemics.

5.1. The White Flies, *Aleurocanthus* spp. (Homoptera: Aleyrodidae)

Though many species of white flies have been reported to complete life cycle on bamboos, however, none of them occurs as serious pests. The nymphs and adults of the whitefly species *Aleurocanthus bambusae* Peal, *A. longispinus* Quaint and Baker, *A. niger*, *A. nigricollis* and *A. obovalis* suck the sap from different species of bamboos. The grubs occur on the leaves of some bamboos, *B. nana* and *D. gigantea*. Another white fly, *Aleurotulus arundinacea* Lamb feeds on the foliage of *B. bambos* in India.

5.2. Bamboo Pit Scale, *Asterolecanium bambusae* Boisduval (Homoptera: Asterolecaniidae)

The nymphs of this scale insect feed on the sap under leaf sheath of *B. vulgaris* and other bamboos in India, East Africa, Kenya, Tanzania and Uganda, Somoa and Ellica islands, Philippines and USA. Quite frequently, they form clusters on the stems. Several species of the genus infest various parts of bamboos, but they are of little economic significance. They include *Asterolecanium delicatum* Green, *A. coronatum* Green, *A. flavoalatum* Green, *A. lanceolatum* Green, *A. logum* Green, *A. pudibundum* Green, *A. rubronumatum* Green, *A. udugamme* Green, and *A. soleonophoides* Green.

5.3. Pseudococcid Scale Insects (Homoptera: Pseudococcidae)

The sap-sucking scale insects are tiny, with their bodies covered in a waxy covering (theca). The wingless female adults and nymphs feed by inserting minute suckers into plant tissues and suck the sap. Eggs are laid in large clusters beneath the female's waxy layer, and the nymphs crawl out after hatching. Male adults, which are winged, survive only for a few days. These scale insects usually secrete a great deal of honeydew, and the damaged bamboo (leaves, branches and culms) shows blackened appearance because of the sooty mould fungus that grows on this secretion. About 40 species of pseudococcid scale species have been reported from Asia as sap suckers on foliage, branches or culms of various bamboos. Some of these species are quite abundant in bamboo stands and cause a general reduction in growing vigour and even the death of bamboo plants.

Some common species in this family with distribution in India are *Antonina indica*, *A. pretiosa*, *A. zonata*. For all these species both female adults and nymphs suck sap from leaf sheaths throughout the year. Two generations occur in a year. The female adult, including its white, outer waxy covering, is about 2.7 mm long and 1.9 mm wide.

5.4. The Bamboo Aphid, *Oregma bambusae* Buckton (Homoptera: Aphidae)

O. bambusae is a major sap sucker and is widely distributed in Indian sub-continent and Sri Lanka and is recorded as a major pest of bamboos (*Bambusa* sp. and *Dendrocalamus* sp.). They are small crawling insects, either green or black in colour colonizing the young shoots and stem. Occasional, small scale outbreaks occur. During outbreaks, the aphids cover the shoots in large numbers. Heavy infestation by these aphids results in withering of young shoots which ultimately die. Older shoots may, however, survive if the leading shoot is not attacked heavily. Usually these aphids cover the shoots entirely from bottom to top. Excessive drainage of sap results in low vitality and stunted growth. A large population of aphids smothers the plant with black fungus on the honey dew secreted by them. Dispersal and migration of the wingless sap suckers to other bamboo culms occur by mechanical means such as breeze or oscillations of bamboos.

5.5. *Oligonychus sachari* (Acariformes: Tetranychidae)

It causes damage by sucking sap from leaves. The damaged leaves show discoloured stripes or spots and subsequently, dry up and fall, resulting in reduced growth and vigour of bamboo plants.

5.6. Thrips (Thysanoptera: Thripidae)

Thrips are minute insects of about 0.5-3 mm in length. They are yellowish brown, bright red or black in colour, and are frequently associated with buds, flowers, leaves or bark. Their mouth parts are asymmetrical. They feed extensively on the foliage sap and make the leaves distorted or spindle shaped. Important species reported as minor pest on foliage (*B. bambos*) are *Androthrips coimbatorensis*, *Bamboosiella bicoloripes*, *Verabahuthrips bambusae* and *Podothrips bicolor*.

5.7. *Notobitus meleagris* Fabricious (Coreid bugs) (Hemiptera: Coriedae)

N. meleagris is a sap sucker found in India, China, Myanmar, Singapore and Vietnam (Fig. 5.7.1.). It is found only on sympodial bamboos and prefers *Dendrocalamus* species. There are five generations in a year. Adults of the fifth generation overwinter when the daily mean temperature is below 25°C and again feed from early spring. Eggs are deposited on shoot sheath or the back surface of leaves and are arranged in two rows containing about 30 eggs in total. Egg stage lasts three to twenty days depending on temperature. Adults and nymphs feed mostly on shoots at 1-2 m height and emit a strong, unpleasant odour when disturbed. Some birds, spiders and wasps are found preying on nymphs of the pest. *N. sexguttatus* often occurs together with *N. meleagris*. Other coreid bugs reported from India on both sympodial and monopodial bamboos are *Acanthocoris scaber* Linn., *Riptortus linearis* Fab. and *R. pedestris* Fab.

5.8. Stink Bugs (Hemiptera: Pentatomidae)

Megarrhamphus hastatus Fab. and *M. truncatus* Westwood, occurring in India, China, Japan, Korea, Malaysia, Myanmar and Vietnam are common pests on rice, sugarcane and other agricultural crops. These species have also been recorded on the foliage of various bamboos, but are of no serious concern.

6. Shoot and Culm Borers

Bamboos are attacked consistently by some important groups of shoot and culm borers belonging chiefly to orders Coleoptera, Lepidoptera and Diptera. They mostly damage the tender culm shoots. During the rainy season when young shoots sprout, the weevils and beetles become more active and make holes in the tender culms to obtain the sap. They lay eggs below the culm-sheath and the larvae coming out from the eggs, make

tunnels through several internodes perforating each node and ending in a hollowed and dead terminal shoot. The larvae completely devour the soft tissues of the young shoots, leaving only the culm sheaths. Due to the damage of the terminal buds, the juvenile culms may die completely or the basal portion may develop multiple branches which adversely affect the commercial value of the crop.

6.1. *Estigmene chinensis* Hope (Coleoptera; Chrysomelidae)

E. chinensis is a major shoot and culm borer with distribution in India, Bangladesh, Myanmar and Sri Lanka (Fig. 6.1.1.). It is commonly known as hispino bamboo beetle and attack *B. bambos*, *B. burmanica*, *B. nutans*, *D. strictus*, *Gigantochloascor techinii* and *Schizostachyumper gracile* during the initial stage of culm growth. The female beetles lay batches of two to four eggs on the surface of the internode under the free part of the culm sheath and cover the eggs with chewed up fragments of leaf. The larva feed gregariously between the outer sheath and the surface of the culm and later bore into the wall of the internode. Each internode may harbour up to five larvae. The larva excavates a small tunnel in the culm wall, which is enlarged into an irregular chamber in course of time. Pupation takes place inside the tunnel. Life-cycle is annual and the beetle emerges during the next rainfall. The tunnelling of the larvae degrades the culm which is sometimes bent at the point of damage. Sometimes, all the culms in a clump are attacked.

6.2. Bamboo Weevils: *Cyrtotrachelus longimanus* Fabricius, *C. buqueti* and *C. dux* Boheman (Coleoptera: Curculionidae)

These curculionid weevils are important borers of young sprouting culms of *D. hamiltoni*, *D. strictus* and other bamboos in northern India, Bangladesh, Sri Lanka and Myanmar. (Fig. 6.2.1. and 6.2.2.) The reddish brown weevils of *C. dux* feed on the tender young culm shoots of bamboos. Mating occurs during monsoons, when the beetles bite small pit on young culms of about one metre height and ultimately oviposit white elliptical eggs singly. Generally, a single culm bears three to four eggs at various places. The eggs hatch after one to two weeks of oviposition. The young grubs bore the internodal wall of the bamboos and make irregular long tunnels from egg pit onwards, passing through the nodes and internodes to the apex of a shoot. These tunnels remain filled with wooden dust and excreta of the borer on soft upper portion of the culm, which readily breaks away from the remaining internodes. The fully grown grub, after a period of four weeks, escapes from the fallen clump in August-September and burrows in loose moist soil for pupation. The pupal period lasts for nearly three weeks. The immature weevil develops inside earthen cell or cocoon by the end of September, but emerges out only when the earthen cell wall softens during monsoon.

The grubs of *C. longimanus* (Fig. 6.2.3.) bore *D. strictus*, *Melocana baccifera* and other species of bamboos in India, Bangladesh and China. They feed in young bamboo shoots downward from the place of entrance of the base of shoot and then retreat by enlarging the upper portion of the culm which later falls down to the ground bearing the fully grown grub. The grub later burrows into the soft rain-loosened soil and undergoes pupation within the fallen buried rotten shoot. The pupal period is very long and lasts for nearly 10 months. The damage is characterised by a long larval tunnel, starting beneath or near the culm sheath, passing internally through several internodes by perforating each node and ending in a hollowed and dead terminal shoot.

6.3. *Myocalandra exarata* Boheman (Coleoptera: Curculionidae)

M. exarata is a minor shoot and culm borer reported from India (Fig. 6.3.1.). The larvae of this oriental curculionid beetles are the secondary borers of green living bamboos; *D. strictus* and *Bambusa* spp. that have been damaged by *Estigmene chinensis* and other pests. The weevils emerge between February to June and oviposits in the wounds and tunnels of the primary borers. On hatching, small grubs emerge out, which later form small grub galleries running longitudinally in the internodal wall. The weevil is only a secondary pest and no epidemic has so far been reported.

6.4. *Olethreutes paragramma* Meyrick (Lepidoptera: Tortricidae)

O. paragramma is a major shoot and culm borer with its occurrence in India, Bangladesh and Pakistan. This moth is a common pest in standing green bamboos (*D. strictus*) in the Indian sub-continent. The moth oviposits on the culm sheath. The young larvae at first feed at the face of the free sheathing bracts, but subsequently tunnels down the soft stem below the bracts and the nodes of growing culms of bamboo *D. strictus* during the rainy season. The fully grown larvae are about 17 mm long, with numerous black tubercles. Pupation occurs in silken cocoons formed between the bract and the node. Heavy infestation by this pest causes death of the young culms.

6.5. *Chelyophora ceratitina* Bezzi (Diptera: Tephritidae)

The infestation by this fly is probably secondary to the *O. paragramma*. The species breeds in shoots of *D. strictus* and has been reported both from India and Bangladesh. The pinkish grey larvae eat out the soft tissues of young shoots, leaving only the culm sheaths of the bamboo. The larvae mature by the end of December. Its allied species *C. striata* Froggatt destroys the shoots of *D. giganteus* in southern India and Sri Lanka.

6.6. *Oligia vulgaris* Bulter (Lepidoptera: Noctuidae)

O. vulgaris is a shoot and culm borer with its distribution in India, China and Japan. Adults are mid-sized moths ranging from 11-21 mm in length, and varying in colour from light to dark brown. Larvae are light purple in colour. There is one generation per year, over wintering as eggs. Larvae of *O. vulgaris* hatch from January to March, depending on the locality. Young larvae feed on wild grass, so called intermediate hosts, mainly *Carex* spp., *Poa* spp., *Triseumbitidum* and *Roegneriaakamoji*. The damaged grass shows wilting. When bamboo shoots are available the larvae mine into the shoots and feed inside and make tunnels in a zigzag manner. There are six larval instars and the fully developed larvae drop to the ground and pupate in cocoons formed with soil and leaf litter just below the ground surface. The pupal stage lasts for about three to four weeks. Adult moths are active at night, with strong phototaxis. Females lay eggs on one side of the leaves of certain grass and stick the other side of the leaves to cover the egg mass containing 30 eggs in a single row.

7. Gall Forming Insects

7.1. *Ceraphron* sp. (Hymenoptera: Ceraphronidae)

These minute wasps lay the eggs on the growing tip of the main culms or side shoots. The insects develop inside culms resulting in swelling of the shoot and subsequent retardation of growth. Wasps escape through a small slit in the middle of the woollen part of the shoot. The apical ends of the shoot that develop into galls, subsequently, dry up.

7.2. Rhizome and Root Feeders

7.2.1. *Dorysthenes walkeri* Waterhouse (Coleoptera: Cerambycidae)

D. walkeri is a rhizome and root feeder of minor importance, distributed in India, Myanmar and China (Fig. 7.2.1.1.). Though it is a primary pest of sugarcane, it also attacks bamboos. Larvae bore into roots and bore inside.

7.2.2. White grubs

Holotrichia spp. have been reported as a minor pest attacking young rhizomes of *B. bambusae*, *B. nutans* and *D. strictus* in India. The beetles lay eggs in sandy soil after the first monsoon rains. The freshly hatched grub is creamy white, C-shaped and about 4-5 mm in length. The grubs that hatch out feeds on the roots and rhizomes both in plantations and nurseries. The damage caused is not serious.

7.2.3. Termites

Several species of termites (*Coptotermes heimi*, *Ceylonitermes indicola*, *Microcerotermes fletcheri*, *Microcerotermes heimi*, *Odentotermes distans*,

Odentotermes feae (Fig. 7.2.3.1.), *Odentotermes microdentatus*, *Odentotermes obesus*, *Odentotermes swallonensis*, *Pseudocapriter mesgoanicus* and *Microtermes obesi* (Fig. 7.2.3.2.) have been reported to feed on bamboo roots, but the damage caused is negligible. A few years of damage of this type results in congestions in culms. While *M. fletcheri* and *M. heimi* have been recorded attacking green clump of bamboos in peninsular India, *Ceylonitermes indicola* were found damaging roots of bamboo culms in Kerala.

8. Post-Harvest Pests of Bamboo

About 45 species of insects have been found associated with harvested and stored bamboos, causing colossal damage and rendering them useless for all practical purposes. Most of the serious pests are all borers, and the important species are from the families of Bostrychidae, Lyctidae, Anobidae and Cerambycidae. The most important are the Bostrychids, comprising 80 genera and 650 species. About 90 species of Bostrychids occur in India Myanmar and Sri Lanka which are polyphagous. In Asia, 16 Bostrychids are reported to attack stored bamboos. These boring beetles are of economic concern and popularly known as 'powder-post beetles', because they turn the bamboos into fine powder by feeding. They are also called as 'ghoon' or shot-hole borers. From the economic point of view, the genus *Dinoderus*, of the family Bostrychidae comprises the most destructive pest of stored bamboos. It may be noted that the starch content of the bamboos at the time of harvest would be responsible for the severity of borer attack (Bhat *et al.*, 2005). A few termites are also known to attack bamboos under storage.

8.1. Shot Hole Borers (Bostrychidae and Lyctidae)

The shot hole borers are the most serious pests of felled bamboos. They are closely related and have similar habitats. They cause immense damage to bamboos as well as to other timbers in India.

8.1.1. *Dinoderus* spp. (Coleoptera: Bostrychidae)

There are three species of *Dinoderus* responsible for causing major damage to bamboos during storage, viz., *Dinoderus brevis* (Fig. 8.1.1.1.), *D. minutus* (Fig. 8.1.1.2.) and *D. ocellaris* (Fig. 8.1.1.3.). They are collectively known as ghoon borers or shot hole borers. They cause immense damage when the bamboos are in the process of drying. Presence of starch, soluble carbohydrates and proteins in the bamboo increases its susceptibility to borer attack. These ghoon borers have three to four generations in a year. The most active period of borer attack is from March onwards. The beetles bore into the cut bamboo through spots where external rind has been damaged. Adults gain entry in to the culm through the cut end. They also bore into the exposed transverse sections of the cut ends and into internal walls of the bamboos.

They construct tunnels either vertically or horizontally and reduce the bamboo to mere dust. The beetles make horizontal tunnels in which the eggs are deposited. The larvae tunnel longitudinally. Adults and larvae feed inside the felled culms. Larvae cause major damage to the felled culms. Life cycle takes about two months for completion. Generation are overlapping under favourable conditions. Infestation is dependent on the technical properties of the culm. The ghoon borers also attack the bamboo even after it has been made into furniture, mats and other finished products.

8.1.2. *Lyctus africanus* Lesne (Coleoptera: Bostrichidae)

It is a flattened, light brown to almost black coloured beetle (Fig. 8.1.2.1.). It attacks *B. bambos* and *D. strictus* throughout the year and the attack is rarely very severe. The female beetle inserts 30-50 eggs in the open pores or cut end of bamboos. Incubation period is one to two weeks. The grubs after hatching starts feeding the wooden tissues, converting it to a very fine powder which remains closely packed in the tunnel. Higher moisture content of the wood is more favourable for the development of the grub. Moisture less than 10 per cent is unsuitable. After about one month of pupal period, small beetle emerges by cutting more or less circular holes. The life cycle of this insect, depending upon the availability of food and moisture within the wood, varies from one to three years. Other species of bostrychid beetles found associated with bamboos are *Bostrychopsis* spp., *Minthea rugicollis* Wlk and *Sinoxylon* spp.

8.1.3. *Heterobostrychus aequalis* Waterhouse (Coleoptera: Bostrichidae)

It is a polyphagous species with a very wide spectrum of food plants and commonest of the larger bostrichid borers of packing cases, boxes, plywood chests, panels, etc. (Fig. 8.1.3.1.). It is also a regular pest of saw mills and other wood based industrial products. The beetle is black cylindrical with a rough hooded prothorax, usually with curved hooks or projections at the distal ends of the elytra, 6-15 mm long. The female lays eggs singly on rough surfaces of the dry bamboos or other host plants from which the bark has been removed. The larvae after emergence bore into the soft portion and make gradually a wide tunnel of about 37 cm length and 6 mm width. The convoluted and intersected tunnels are tightly packed with fine dust. The host bamboo is reduced into a powdery mass. The life cycle of the beetle is annual.

8.1.4. *Stromatium barbatum* Farb (Coleoptera: Cerambycidae)

Stromatium barbatum is the last of the borer groups which attack the dried bamboos (Fig. 8.1.4.1.). The galleries of this borer are cylindrical, but during heavy infestation get intermingle. In cross section, these look like circular holes. *S. barbatum* is primarily a pest of packing cases and converted seasoned timbers. It is also common pest of furniture, plywood and wood works in buildings. Like other borers, this beetle

also deposit eggs in small holes in rough surface of the host wood, crevices or tissues. Smooth surfaces are usually avoided. The larval tunnels are tightly packed with a fine flour dust which is normally ejected out at intervals. The larvae produce distinctly audible sound of scraping of wood with mandibles.

8.1.5. *Chlorophorus annularis* Fabricius (Coleoptera: Cerambycidae)

This species occurs widely in India, China and New Guinea and is primarily a borer of dry bamboos (Fig. 8.1.5.1.). The beetle is 8-15 mm long, ochreous yellow with a dark brown or black pattern of curved and rounded spots on the elytra and pronotum. The emergence of this beetle takes place during May-September, but it may be delayed according to the dryness of the bamboos. Even the finished products are being attacked by this beetle. It has normally one generation in a year and is frequently carried to other countries through infested materials. The other cerambicid borers that attack *D. strictus* and other bamboos are *Diboma postica* Gahan, *Merionoeda nigriceps* White, *Purpuricenus sanguinolentus* Oliver and *Ropica signata* Pic.

8.1.6. *Cryptotermes dudleyi* Banks (Isoptera: Kalotermitidae)

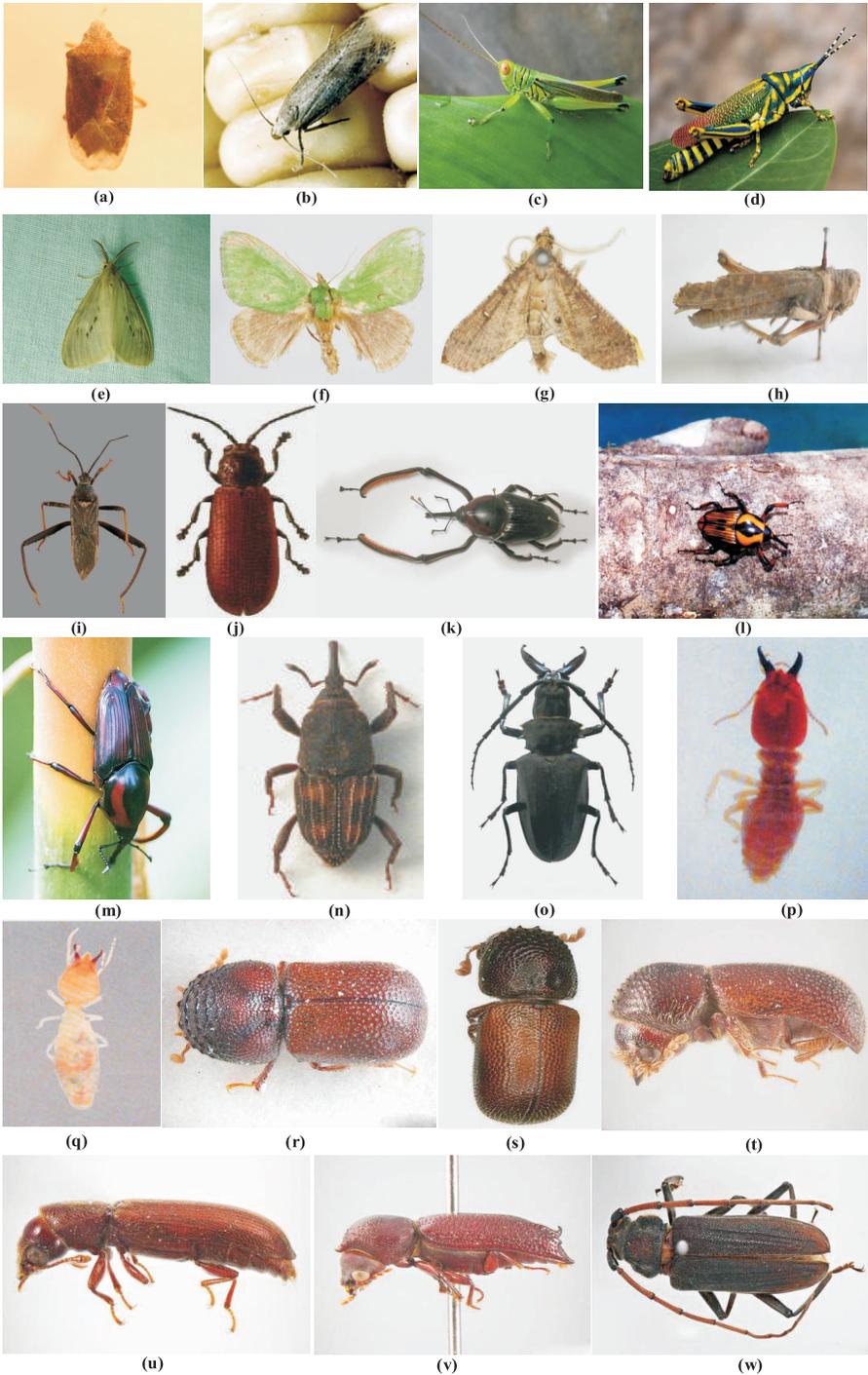
This is commonly known as American powder post termite (Fig. 8.1.6.1.). It is an introduced species and is restricted in distribution to the coastal regions in Odisha, West Bengal and Daman as well as in some parts of Bangladesh, where it has been found damaging and destroying all bamboo structures in houses. All types of bamboo constructions, including split bamboos used as rafters or matted walls in houses are seriously attacked by this species. The attack is usually serious and the infested materials get completely riddled with excavations to be ruined within a short period. This necessitates frequent replacement of the material. The attack by this species resembles a typical bostrychid attack with small holes appearing on the outer hard rind portion.

8.1.7. *Coptotermes heimi* Wasm (Isoptera: Rhinotermitidae)

This termite is widely distributed throughout India and in some parts of Pakistan. It is a highly polyphagous species. It has as many as 35 species of plants as its host in addition to bamboos. It eats away the inner soft portion along the fibre leaving behind the outer rind surface intact. In seriously infested bamboos, the inner portion is honey combed.

9. Pest Management

Generally, no serious attention is being given to manage the pests of standing bamboos. Also, reliable data are not available on the losses caused so as to warrant control



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Figures showing different types of bamboo insects:

a. *Udonga montana* (Fig. 2.1.1.), b. *Sitotroga cerealella* (Fig. 2.2.1.), c. *Hieroglyphus banian* (Fig. 3.3.1.), d. *Poecilocerus pictus* Fab. (Fig. 3.4.1.), e. *Pantana pluto* (Fig. 4.9.1.), f. *Parasa bicolour* (Fig. 4.10.1.), g. *Massepha absolutalis* (Fig. 4.13.1.), h. *Schistocera gregaria* (Fig. 4.16.1.), i. *Notobitus meleagris* (Fig. 5.7.1.), j. *Estigmaena chinensis* (Fig. 6.1.1.), k. *Cyrtotrachelus buqueti* (Fig. 6.2.1.), l. *C. dux* (Fig. 6.2.2.), m. *C. longimanus* (Fig. 6.2.3.), n. *Myocalandra exarata* (Fig. 6.3.1.), o. *Dorysthenes walker* (Fig. 7.2.1.1.), p. *Odentotermes feae* (Fig. 7.2.3.1.), q. *Microtermes obesi* (Fig. 7.2.3.2.), r. *D. brevis* (Fig. 8.1.1.1.), s. *D. minutes* (Fig. 8.1.1.2.), t. *D. ocellaris* (Fig. 8.1.1.3.), u. *Lyctus africanus* (Fig. 8.1.2.1.), v. *Heterobostrychus aequalis* (Fig. 8.1.3.1.), w. *Stromatium barbatum* (Fig. 8.1.4.1.), x. *Chlorophorus annularis* (Fig. 8.1.5.1.) and y. *Cryptotermes dudleyi* (Fig. 8.1.6.1.).

measures. Though in the past, many broad-spectrum pesticides would have been recommended wherever some outbreak of defoliators or sap-suckers occurred, these have not been practised as a routine. In modern times, we have to avoid use of insecticides and resort to pest management strategies in bamboo stands involving cultural and biological methods.

In natural stands of bamboos, the pest populations are regulated due to the predator-prey interactions and presence of other useful components of biodiversity. However, when intensive cultivation practices are adopted outside the natural stands, the biodiversity and the natural habitat are lost which can result in pest outbreaks.

Most damage to post-harvest bamboos, including finished products, is caused by the Coleopteran beetles. Varma *et al.* (1988) tested several insecticides and two pyrethroids – cypermethrin and permethrin to be found effective in reducing borer attack. Treating the green bamboo with preservative chemicals can also increase the service life (Kumar and Dobriyal, 1990). However, some of the field trials in the open storage yards have shown that proper stacking methods alone can reduce borer attack and some prophylactic treatments can further offer better protection.

Some of the traditional practices which are eco-friendly and easy to replicate like water soaking, baking over open fire, clump curing, biological preservative, etc. are promising, but need to be taken up on a large-scale and methods of treatment to be standardised to suit the local conditions.

The occurrence of starch during the felling season is another factor to be considered. The starch content will vary based on the season, phases of moon, status of flowering, etc. The logic behind the traditional knowledge is to cut the bamboos at a time when the starch content would be low. Paduvil (2008) observed that bamboos harvested during dry season and before flowering are highly susceptible to borer attack, while those harvested during wet season are comparatively resistant, and those harvested after flowering were completely resistant to borer attack. Regarding moon phases, no empirical relationship exists between the waxing and waning phases to borer attack.

10. Conclusion

In general, standing bamboos, especially natural stands in India are free from major pest problems, although some defoliators, sap-suckers and culm and shoot borers can become potential threats. When bamboos are grown as plantations under intensive management practices, there can be pest outbreaks which require monitoring. The seed pest, *Udonga montana* can affect seed production and thus can have impact on establishment of new plantations.

Bamboos during storage and as finished products are susceptible to serious damage by borers, mainly the *Dinoderus* spp. This is a serious problem in bamboo industry and preventive or remedial measures of control will have to be adopted depending on the severity of borer infestation. The traditional knowledge available with the forest dwellers on bamboo preservation is to be collected and the same needs to be scientifically tested and evaluated.

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