Other Aphids

Chucallis bambusicola Tak., ***Pseudoregma albostriata*** Liao, ***P. alexanderi*** Tak. and ***P. koshunensis*** Tak. are found on shoots of *Miscentus* sp., *Sinocalamus oldhami* and *Dendrocalamus latiflorus,* but in low numbers and cause only minor damage.

Other common aphids include ***Astegopteryx insularis*** van der Goot, ***Takecallis arundinariae*** Essig., ***T. taiwanus*** Tak., ***Melanaphis bambusae*** Full., ***Pseudoregma bambusicola*** Tak. and ***Ceratovacuna* spp.** which occur in China, Indonesia, Japan and Malaysia. All these species feed on the back side of leaves and are capable of causing considerable damage. ***P. bambusicola,*** for instance, feeds on sap from bamboo culms and tips, causing reduction in vigour.

Pseudococcid Scale Insects (Homoptera: Pseudococcidae)

More than 150 species of scale insects belonging to the families Aclerdidae, Margarodidae, Pseudococcidae, Asterolecaniidae and Diaspididae have been reported as pests on bamboos in Asia (Yan Aojin 1985; Wang Ziqing and Zhang XJ 1987; Wu Shijun 1992; Xu Tiansen et al. 1993). 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 sucking 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 a blackened appearance because of the sooty mould fungus that grows on this secretion.

About 40 species of pseudococcid scale species have been reported 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.

Nesticoccus sinensis Tang

DISTRIBUTION

China.

HOSTS

Phyllostachys spp. and *Arundinaria* spp.

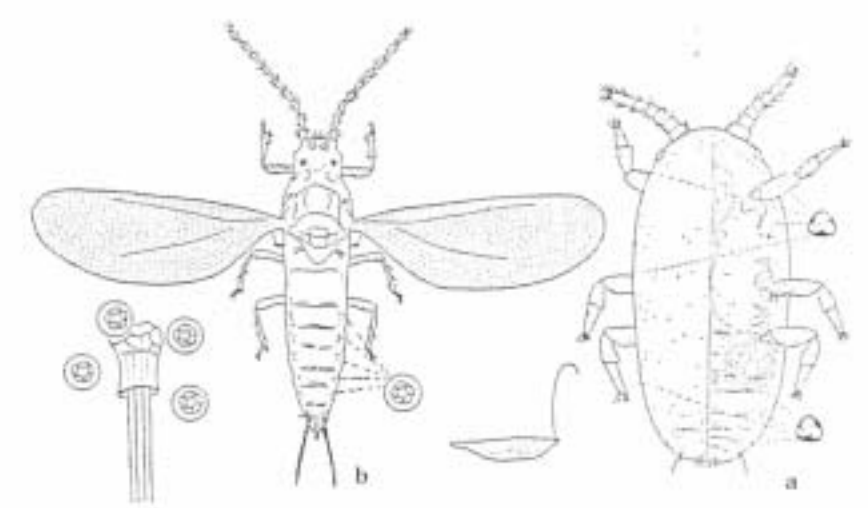


Fig. 34: ***Nesticoccus sinensis*** a: 1st nymph instar in its waxy covering; b: male adult

BIOLOGY

The pear-shaped female adults are 2.2-3.3 mm long and brownish in colour, but are covered with a greyish, waxy covering. There is only one generation per year. Female adult sucks sap from leaf sheaths from June to the following May. Nymphs, which also have the waxy

covering (see Fig. 34a), pass through three instars in 6-7, 15-22 and 10 days, respectively, in May-June, and cause the same damage as female adults.

CONTROL

About 20-50% of the insect is parasitized by encyrtid wasps (Xie Guolin 1983).

Eriococcus rugosus Wang

DISTRIBUTION

Central China.

HOST

Phyllostachys pubescens.

BIOLOGY

The egg-shaped female adults are 3.1 mm long and covered with a white, waxy covering. There is one generation per year. Sap-sucking goes on throughout the year, with nymphs feeding on leaf sheaths and female adults preferring twigs (Zhang Guoxian et al. 1992).

Other Pseudococcid Scale Insects

Antonina crawii Cockerell is widespread in all bamboo-growing areas in China. Both female adults and nymphs suck sap from leaf sheaths throughout the year. Two generations occur per year. The female adult, including its white, outer waxy covering, measures about 2.7 mm long and 1.9 mm wide (Xu Ji 1983).

Other common species in this family include ***Eriococcus transversus*** Green, ***Antonina indica*** Green,

A. pretiosa Ferris, ***A. zonata*** Green, ***Chaetococcus bambusae*** Maskell, ***Trionymus pulverarius*** Newst. var. ***bambusae*** Green, ***Heliococcus bambusaniae*** Wang and ***Kiritshenkella magnotubulata*** Borchs. These are found attacking *Phyllostachys, Bambusa, Dendrocalamus* and *Sinocalamus* species in China, India, Japan, Sri Lanka, and some Southeast Asian countries.

A NOTE ON CONTROL OF PSEUDOCOCCID SCALE INSECTS

Spraying 0.04% water solution of dimethoate on young nymphs, and injecting 50% methamidophos at the rate of 1.5 ml per culm to control adult females are effective measures (Hu Heyuan and Min ZJ 1988; Zhang Guoxian et al. 1992).

Pit Scale Insects (Homoptera: Asterolecaniidae)

Pit scale insects are very common on bamboos. There are over 50 species in this group, mostly classified to genera ***Asterolecanium*** and ***Bambusaspis***, but only a few of them can be considered important.

Asterolecanium bambusae Boisduval

DISTRIBUTION

China, India and the Philippines (Dayan 1990).

HOST

Bambusa vulgaris.

BIOLOGY AND CONTROL

The scale insect feeds on the sap from culm sheath and forms clusters on the stems. Because of the glassy wax

covering on mature females, and subsequently on eggs, chemical control is difficult. Singh and Bhandari (1988) recorded a coccinelid, *Cryptolacmus* sp., as an effective predator on the scale. Systemic insecticides such as dimethoate has also been recommended (Hamon 1980).

There are several other species of the genus ***Asterolecanium*** — such as ***A. delicatum*** Green, ***A. flavoaliatum*** Green, ***A. coronatum*** Green, ***A. lanceolatum*** Green and ***A. logum*** Green — reported as infesting various parts of *Bambusa* and *Dendrocalamus* species. Other recorded species include ***A. pudibundum*** Green, ***A. soleonophoides*** Green, ***A. rubronumatum*** Green and ***A. udagammae*** Green. None of these are known to be of economic significance.

Bambusaspis hemisphaerica Kuwana

DISTRIBUTION

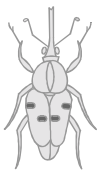
China and Japan.

HOSTS

Phyllostachys spp., *Bambusa metake* and *Arundinaria chino.*

BIOLOGY

The female adult is characterized by the semiglobose, waxy covering, which is 2.5-3 mm long and greenish-yellow in colour. The scale occurs in 1-2 generations per year, and causes damage through female adults and nymphs which suck sap from twigs and leafstalks (Yan Aojin 1992).



Other Pit Scale Insects

Bambusaspis bambusae Boisduval, ***B. masuii*** Kuwana and ***B. miliaris*** Boisduval cause similar damage on *Bambusa hemisphaerica* in China, Japan, India, Sri Lanka and the Philippines.

Armoured Scale Insects (Homoptera: Diaspididae)

About 60 species of armoured scale insects have been found on various bamboos, and some of them are considered important with regard to the damage they cause to bamboo culms and leaves.

Kuwanaspis pseudoleucaspis Kuwana

DISTRIBUTION

China, Japan and Korea.

Fig. 35: ***Kuwanaspis pseudoleucaspis*** on bamboo culm

HOST

Phyllostachys spp.

BIOLOGY

The female adult, along with its waxy covering, is 1.1-3 mm long, 0.4-0.8 mm wide and white in colour. There are two generations per year. Both nymphs and female adults feed in groups on culm sap from June to the following April. In severe outbreaks, the culm shows a white appearance because of the large number of scales present, and become commercially valueless. There is also a general reduction in the growth vigour of the stands.

CONTROL

About 21% and 60% of adult females in the two generations, respectively, are parasitized by a chalcid wasp (Hymenoptera: Encyrtidae). The ladybird beetles *Chilocorus kuwanae* Silvestri and *Telsimia* sp. prey on eggs and newly-hatched nymphs (Yang Mingzhen et al. 1984; Yan Aojin et al. 1985).

Kuwanaspis howarai Cooley usually occurs together with ***K. pseudoleucaspis***, and has similar life cycle and damaging habits. The ladybird beetle *Chilocorus kuwanae* feeds on this scale also (Feng Zongxuan et al. 1987).

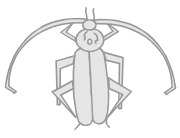
Unachionaspis bambusae Cockerell

DISTRIBUTION

China.

HOST

Phyllostachys spp.



BIOLOGY

This scale insect found on bamboo leaves has three generations per year. The pear-shaped, waxy covering of female adults is 1.8-2.5 mm long and white in colour. The pest prefers feeding on young leaves in the lower crown, and a heavy attack can cause defoliation.

CONTROL

About 15-30% of the scale is parasitized by *Aphytis chrysomphali* Mercet, and 5-10% preyed upon by the ladybird beetle *Telsimia* sp. (Wu Shijun 1981).

Other Armoured Scale Insects

Several species in the genus ***Odonaspis*** — such as ***O. canaliculatus*** Green, ***O. penicillata*** Green, and ***O. inusittatus*** Green, ***O. senireta*** Cockerell, ***O. simplex*** Green and ***O. elongata*** — are reported on *Phyllostachys* spp. and *Bambusa vulgaris* in China and India. In India, several of these are found to infest leaf petioles and the basal part of leaf sheaths of *B. vulgaris.* But they are pests of minor economic importance. ***O. penicillata*** occurs one generation per year in China and causes damage through nymphs and female adults which suck sap from culms and branches. Adults emerge in late June or early July and overwinters on bamboo plants.

The armoured scale insects found on leaves are mostly classified to the genera ***Unachionaspis***, ***Chionaspis*** and ***Greenaspis***, such as ***U. signata*** Maskall, ***C. bambusae*** Cockerell, ***C. arundinaria*** Green, ***C. spiculata*** Green, ***G. elongata*** Green and ***G. bambusifoliae*** Takahashi.

A NOTE ON CONTROL OF ARMOURED SCALE INSECTS

Almost all armoured scale insects, especially those found on culms, prefer to feed on old plants and favour

wet, shaded sites. Heavy attacks usually occur in dense, over-mature stands. Prevention of these conditions through silvicultural measures, such as reasonable and selective thinning, is effective and primary for the suppression of the insects. Various natural enemies, mainly chalcid wasps and ladybird beetles, play an important role in controlling the insects and should be properly protected. Because of the waxy covering of the nymphs and female adults, chemical control is not very feasible. However, spraying 0.05% water solution of malathion is recommended for controlling those species feeding on culms (Feng Zonxuan et al. 1987), while culm-cavity injection of systemic insecticides can be employed against outbreaks of scales feeding on leaves (Zhang Guoxian et al. 1992).

White Flies (Homoptera: Aleyrodidae)

Many species of white flies complete their life-cycle on bamboo, but none of them are reported as serious pests.

Aleurocanthus arundinacea Lamb

DISTRIBUTION

India.

HOST

Bambusa bambos.

BIOLOGY

This white fly feeds on leaf sap and lays eggs on leaves. Young larvae move for a short while before settling down to feed on plant sap (Browne 1968).

Other White Flies

The nymphs and adults of the species ***Aleurocanthus bambusae*** Peal, ***A. longispinus*** Quaint and Baker, ***A. niger***, ***A. nigricollis*** and ***A. obovalis*** suck sap from different species of bamboos. Grubs occur on the leaves of *Bambusa nana* and *Dendrocalamus giganteus.*

Leaf Mites (Acariformes: Tetranychidae)

Twelve species of leaf mites have been reported on bamboos in China (Cui Yunji 1989), India (Gupta 1978), Japan (Saito and Ueno 1979) and the Philippines (Dayan 1990). These species cause damage by sucking sap from leaves. The damaged leaves show discoloured stripes or spots and subsequently, dry up and fall, resulting in reduced growth vigour of bamboo plants.

Schizotetranychus nanjingensis Ma et Yuan

DISTRIBUTION

China.

HOST

Phyllostachys spp.

BIOLOGY

The pest occurs in 6-8 generations per year in Zhejiang, China, overwintering as adult mites or eggs. From April to November, the mites feed on the back side of leaves in groups under silk webs, which are dense and white in colour.

Other Leaf Mites

Schizotetranychus bambusae Reck occurs in about ten generations a year and feeds individually from April

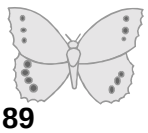
to November under thin webs on the back side of leaves. ***Aponychus corpuzae*** Rimando, occurring in 7-8 generations a year, feeds individually without the protection of silk webs. The two species often occur together with ***S. nanjingensis*** in China. ***S. celarius*** Banks and ***A. corpuzae*** are reported as minor pests on bamboos in Japan. Reared under controlled environments in laboratory, the two species completed 26 and 22 generations, respectively, per year (Saito and Ueno 1979). ***S. floresi*** is reported in the Philippines (Dayan 1990), ***Oligonychus sachari*** in India (Gupta 1978) and ***O. uruma*** Ehara in Taiwan (Chen Mingfa and Cheng CL 1992).

A NOTE ON CONTROL OF LEAF MITES

High mortality rates of the pest were observed resulting from attack by a predatory mite. Culm cavity injection of 50% or 40% dimethoate, 1.5 ml per culm, is recommended as a chemical control measure (Yu Huaxing and Shi Jimao 1991; Shi Jimao et al. 1992). ***S. celarius*** is attacked by the predatory mite *Typhlodromus bambusae* (Yamamura 1987).

Thrips

Species from six genera have been reported as minor pests of foliage on various species of bamboos. The important ones include *Veerabahuthrips bambusae* Ramakrishna, *Androthrips coimbatorensis* Ramakrishna, *Bamboosiella bicoloripes* Ananthakrishnan and *Podothrips bicolor* Seshadri and Ananthakrishnan. All these have been reported to damage leaves. Other genera of thrips found in India are: *Ablemothrips, Agriothrips, Allorothrips, Antilliothrips, Baliothrips, Bolacidothrips, Ctenidiothrips, Ctenothrips, Dorcadothrips, Haplothrips, Helionothrips, Karnyothrips, Praepodothrips* and *Stephanothrips.*



DISTRIBUTION

Thrips have been reported from different parts of India.

HOST

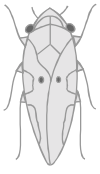
Bambusa bambos harbours several species of thrips.

BIOLOGY

Thrips are minute insects of about 0.5-3 mm in length. These sap-suckers are yeelowish-brown, bright red or black in colour, and frequently associated with buds, flowers, leaves or bark. Their mouth parts are asymmetrical.

DAMAGE CAUSED

They feed extensively on the foliage sap and make the leaves distorted or spindle-shaped.



3. SHOOT AND CULM BORERS

Bamboo Shoot Weevils (Coleoptera: Curculionidae)

There are some 18 weevil species attacking bamboo shoots. Both adults and larvae of these weevils feed on shoots, although larvae, which bore holes on bamboo shoots, are responsible for most of the damage. The damage caused by weevils usually results in the death of very young shoots, or deformed and stunted growth of new culms with very closely formed nodes at the feeding site. The larger species are the most common and destructive on sympodial bamboos.

- ***Cyrtotrachelus buqueti*** Guer
- ***C. longimanus*** Fabricius
- ***C. dux*** Boheman

DISTRIBUTION

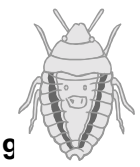
Bangladesh, China, India, Myanmar and Sri Lanka.

HOSTS

Lingnania chungii, Bambusa textilis, B. pervariabilis, Sinocalamus oldhami, Dendrocalamus strictus, D. hamiltonii, Melocanna baccifera and some other bamboos.

BIOLOGY

Adults are 18-38 mm long and vary in colour from light brown to dark reddish-brown. The legless larvae are cream-white in colour, but turn light brown when



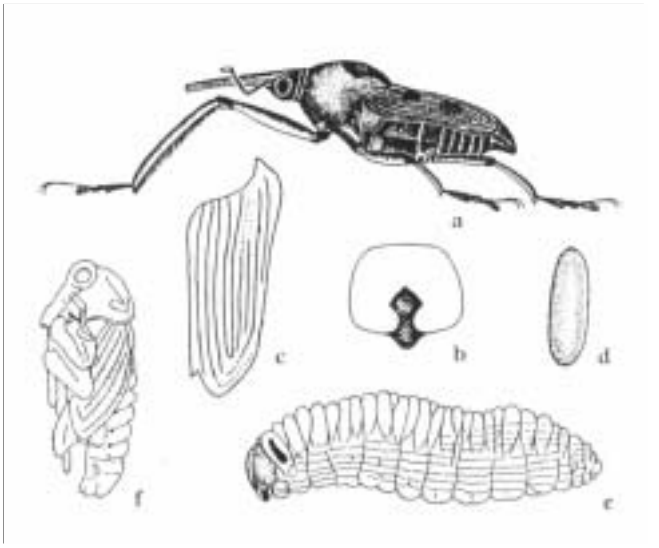


Fig. 36: ***Cyrtotrachelus buqueti*** a: adult;
b: protergum; c: forewing; d: egg; e: larva; f: pupa

they are fully fed. The three species have very similar life cycle and damaging habits (Chen 1928; Liu Yongzheng 1978; Wu Shixiong 1979). There is only one generation per year, overwintering as adult in cocoons in the soil. Adults and larvae can be found on bamboo shoots from May to early October. The overwintering adults emerge from the soil during spring and summer months when bamboo shoots are available. They feed by sucking sap from the upper part of shoots. Eggs are laid individually in large feeding holes and only 1-3 eggs are deposited on each shoot. The egg-laying site can be identified by a group of fibre sticking out of the shoot surface. The larvae feed and bore inside the bamboo shoots, forming vertical tunnels. They pass through five instars in 12-15 days. Fully fed larvae drop to the ground, burrow into the soil and pupate 2-3 weeks later in cocoons made with soil at 10-30 cm depth. Adults emerge within 15 days after pupation.

Although they often occur together, ***C. buqueti*** is usually found on bamboo species with culms smaller than 2 cm in diameter, while ***C. longimanus*** prefers those with larger culms.

Fig. 37: Adult of ***Cyrtotrachelus buqueti***

Fig. 38: Adult of ***Cyrtotrachelus longimanus***

DAMAGE CAUSED

These weevils are important borers of young sprouting culms. Damage is characterized by a long larval tunnel, starting beneath or near the culm

sheath, passing internally through several internodes with perforation of nodes and ending in a hollowed and dead terminal shoot. These tunnels are filled with wooden dust and excreta. Wind, rain, feeding by woodpeckers, etc. can cause the affected culms to readily break. A single larva is capable of destroying a culm and inducing development of multiple shoots of little commercial value.

CONTROL

Digging and removal of damaged culms and shoots have been recommended to control the weevils (Dayun and Shen 1987). Keeping a low culm density is another method suggested since damage is less in well-thinned areas (Singh and Bhandari 1988). Beeson (1941) recommended capture and destruction of the beetles at the beginning of the monsoon. Liu Nanxing et al. (1988, 1989) reported the use of nematodes to control the larger bamboo shoot weevils.

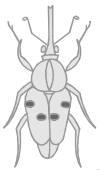
Otidognathus davidis Fabricius

DISTRIBUTION

Widespread in central and southern China, and Vietnam and a few other Southeast Asian countries.

HOSTS

The insect attacks over 60 bamboo species, mainly *Phyllostachys* spp. and some species of *Pleioblastus, Pseudosasa, Sinobambusa, Indocalamus* and *Semiarundinaria* (Wang Haojie et al. 1995).



BIOLOGY

Xu Tiansen (1964) has reported the biology of the weevil in detail. The adult weevil is about 15-17 mm long and dark reddish-brown or black in colour. There

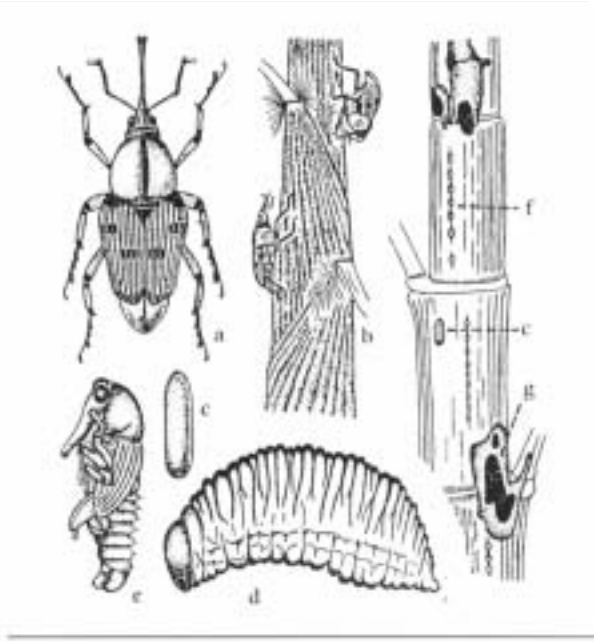


Fig. 39: ***Otidognathus davidis*** a-b: adults; c: egg; d: larva; e: pupa; f: feeding holes; g: damage caused

is a vertically elongate, black spot at the centre of the protergum of the adult. There is one generation per year. In China, adults and larvae occur in bamboo stands from early April to early June and from mid April to mid June, respectively. Adults come out from the soil, where they overwinter, when most bamboo shoots in the stand are about 2 m in height. They feed on sap from the upper part of the shoots and leave vertical lines of feeding holes on the outer surface of the shoots. Eggs are deposited individually in feeding holes and take about three days to hatch. The larvae bore beneath the sheath near the nodes, and feed on branch buds when shoots get older. There are five instars in larval stage. The fully developed larvae drop to the ground, burrow into the soil and pupate in cocoons made up of soil at 8-15 cm in depth. Adults emerge about 30 days later and overwinter in the cocoons.

DAMAGE CAUSED

Both adults and larvae feed on bamboo shoots and cause damage more serious than that caused by

Fig. 40: Adults of ***Otidognathus davidis*** feeding on shoot

Fig. 41: Damage on *Phyllostachys pubescens* caused by ***Otidognathus davidis***

***Cyrtotrachelus* spp.** Up to 80 larvae can be found on a single shoot and results in stunted and deformed culms, with very few branches, many holes and closely formed nodes.

Two other species of the genus — ***Otidognathus nigropictus*** Fab. and ***O. rubriceps*** Chen — sometimes occur together with ***O. davidis*** but cause only minor damage.

CONTROL

O. davidis can be effectively controlled by injecting systemic insecticides into the basal part of bamboo shoots in the case of species with large-sized culms, and by aerially spraying contact insecticides in the case of small-sized bamboos (Wang Haojie et al. 1993, 1994). Turning and loosening of soil in bamboo stands in winter months can kill some adults in the soil, or expose them to natural enemies and cold weather, thus reducing the population density of the pest in the following year (Xu Tiansen 1964).

Myocalandra exarata Boheman

DISTRIBUTION

India.

HOSTS

Bambusa polymorpha and *Dendrocalamus strictus.*

BIOLOGY

Adults of this secondary pest emerge from February to June, peaking in April. Eggs are laid in wounds or tunnels on shoots caused by bamboo hispine beetle or other primary borers. Larvae bore and make longitudinal tunnels in the internodal wall. No

outbreaks have been reported, and the pest is considered to be of minor economic importance.

CONTROL

Cutting and disposal of attacked culms is considered the best method to check the spread of the insect (Beeson 1941).

Shoot-boring Noctuids (Lepidoptera: Noctuidae)

Seven bamboo shoot-boring noctuids have been reported on various *Phyllostachys* species. Among

Fig. 42: Adult moth of ***Oligia vulgaris***

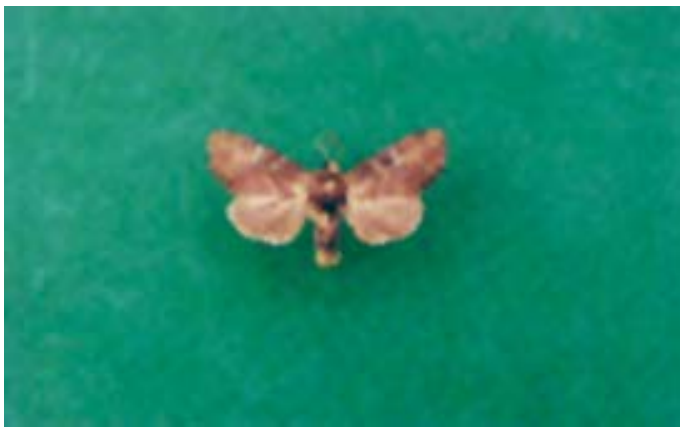


Fig. 43: Adult moth of ***Oligia apameoides***

them, ***Oligia vulgaris*** Butler can cause up to 90% death of new shoots. ***O. apameoides*** Graudt and ***O. vulnerata*** Butler, reported only in China, can also cause considerable damage. ***Apamea cuneata*** Leech, ***A. kumaso*** Suqi, ***A. repetita conjuncta*** Leech and ***Dichromia claripennis*** Butler are minor pests of shoots. It is common to find several of these species occurring together in bamboo stands. The damage is caused by larvae, which bore inside new shoots and cause the death of damaged shoots in most cases. Thus, damaged shoots and culms will have several feeding holes and tunnels. All these shoot borers have very similar life history and damaging habits.

Oligia vulgaris Butler

DISTRIBUTION

China, India and Japan.

HOST

Phyllostachys species.

BIOLOGY

In China, the biology of this and other shoot-boring noctuids has been studied in detail by Ma Junchao (1934) and Chen Yijin (1982). Adults of the shoot borers are mid-sized moths, ranging from 11 to 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, overwintering 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 *Roegneria kamoji, Triseum bitidum, Poa* spp. and *Carex* spp. The damaged grass shows wilting stems. When bamboo shoots are available, the larvae mine into the shoots

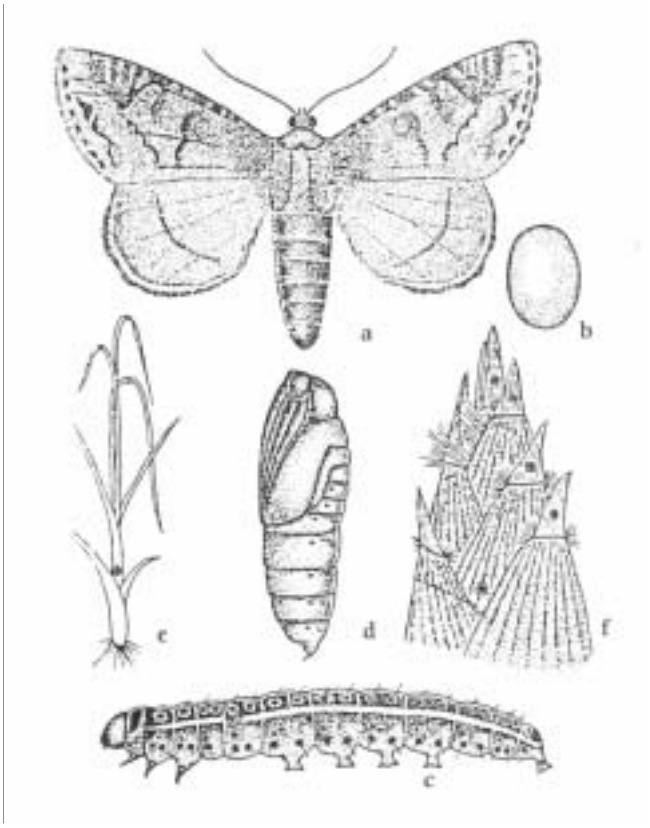


Fig. 44: Life stages of and damage caused by ***Oligia vulgaris*** a: adult; b: egg; c: larva; d: pupa; e: wilting of damaged grass; f: bores on sheaths of shoot

and feed inside and make tunnels running in different directions. Damaged shoots can be identified by the feeding holes on sheaths and the debris of bored tissue on the outer surface of the shoots. 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 3-4 weeks. Adults moths are active at night, with strong phototaxis. Females lay eggs on one side of leaves of certain grass and stick the other side of the leaves to cover the egg mass, which will contain approximately 30 eggs in a single row. Eggs

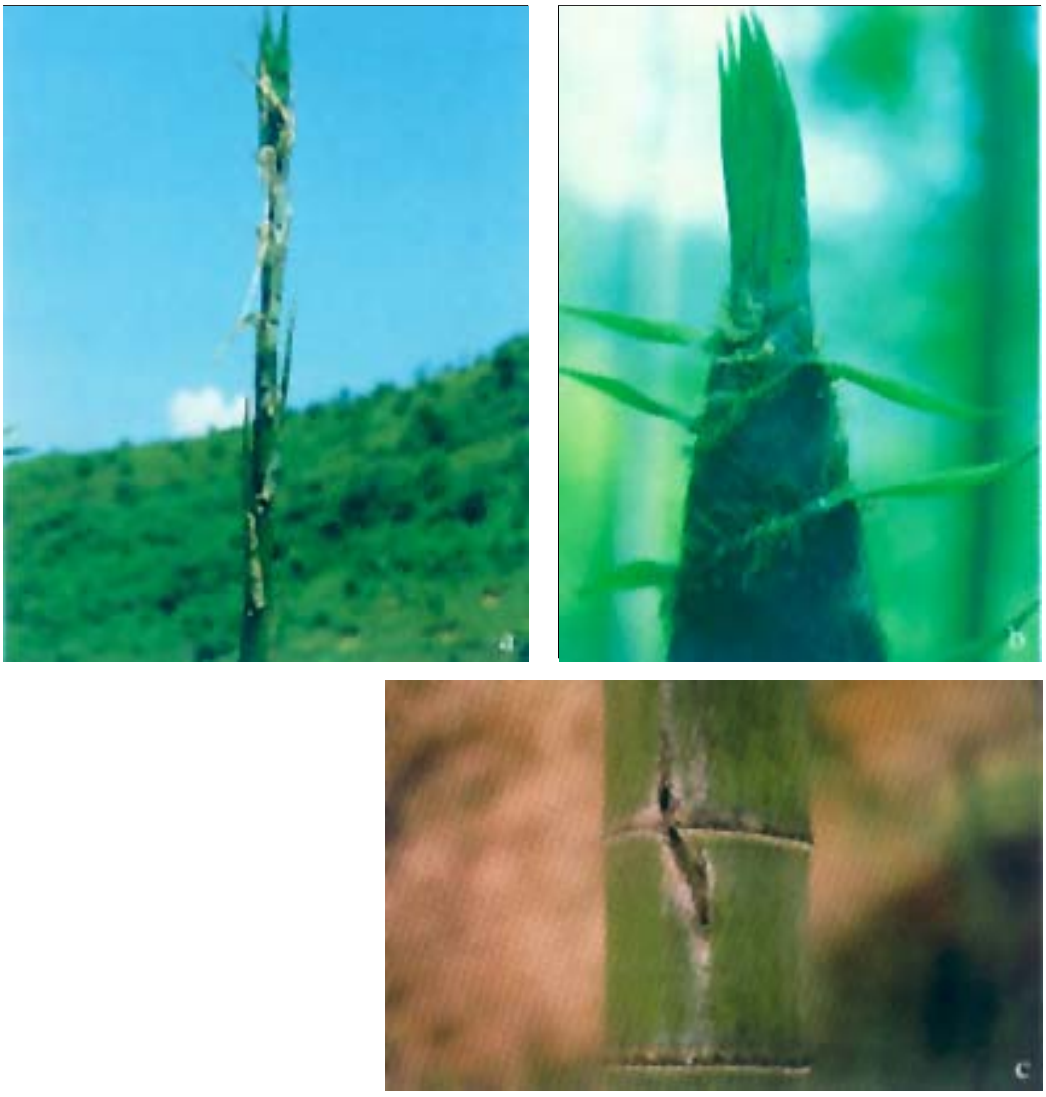


Fig. 45: Damage caused by shoot-boring noctuids a: damaged shoot of *Dendrocalamus* sp.; b: bores on young sheaths of shoots of *Phyllostachys pubescens*; c: bores on the culm of *Phyllostachys pubescens*

are sometimes laid also on sheaths touching the ground and on leaves of lower branches.

CONTROL

The most effective and simplest control measure against ***O. vulgaris*** is to keep bamboo stands free from

those intermediate host grass by soil-turning or spraying herbicides in winter season. Most larvae will die from hunger before bamboo shoots become available. Light-trapping adults and removal of damaged shoots in shooting season can keep the population of other bamboo shoot borers reasonably low (Zheng Hanyi 1962; Xu Tiansen and Sun Yongchun 1962; Zheng Jianjia et al. 1992; Zheng Guohua et al. 1994).

Shoot Flies (Diptera: Anthomyiidae and Tephritidae)

More than 20 fly species have been found to attack bamboo shoots. Several ***Pegomyia*** species are found feeding on young bamboo shoots. ***Pegomyia kiangsuensis*** Fan and ***P. phyllostachys*** Fan are the most common and widespread in China.

Pegomyia kiangsuensis Fan

DISTRIBUTION

China.

HOST

Phyllostachys spp.

BIOLOGY

Occurs one generation a year and overwinters as pupae in the surface layer of the soil. Adults emerge during April-May. They prefer to feed on shoot sap and are commonly found gathering on wounds on shoots. Eggs are laid in clusters on the inner surface of sheaths and take 4-5 days to develop. On hatching, larvae move downwards from the sheaths to the nodes, where they feed on shoot tissue and cause rotting. Larvae take 20-25 days to develop fully and then drop to the ground.

Fig. 46: Feeding tunnels caused by shoot flies on *Phyllostachys pubescens*

DAMAGE CAUSED

The damaged shoot will die if there are several larvae feeding on it.

CONTROL

Reasonable culm density and timely clearing in bamboo stands are unfavourable to the pest. Soil-

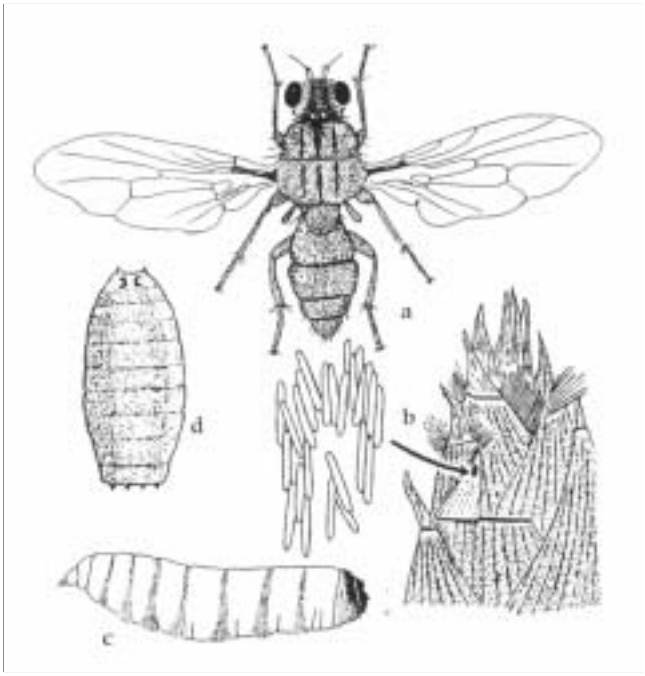


Fig. 47: Life stages of ***Pegomyia phyllostachys***
a: adult; b: eggs and egg-laying site; c: larva;
d: pupa

turning in winter, trapping with fresh shoot pieces during adult stage and removal of damaged shoots in shooting season are all good practices for keeping the population level of the insect under control.

P. phyllostachys has a life cycle similar to that of ***P. kiangsuensis***. It is regarded as a secondary pest insect because its larvae can only feed on weak and dying shoots, and hence, no control measures are required (Xu Tiansen and Ge Zhenghua 1966).

Other Shoot Flies

Chelyophora ceratitina Bezzi (Diptera: Tephritidae) is found on *Dendrocalamus strictus* in Bangladesh and India. Its allied species ***C. striata*** Frogatt destroys shoots of *D. giganteus* in India and Sri Lanka (Beeson 1941).

C. ceratitina is thought to be a secondary pest that follows an attack by ***Olethreutes paragramma*** (Beeson 1941; Singh and Bhandari 1988). The pinkish-grey larvae consume the soft tissue of young shoots, leaving only the culm sheaths. Larvae mature by the end of December.

Some 11 chlorpidi and anthomyidi flies — such as ***Acanthonevra formosana*** Enderlin, ***Acroccratitis plumosa*** Hendel, ***Gastrozona maccuarti*** Hendel, ***Ptilona persimilis*** Hendel and ***Parahydrataea jacobsone*** Stein — are found attacking edible bamboo shoots after harvesting. Adults lay eggs on harvested fresh shoots or nearby sites, and larvae bore into the shoots for feeding, causing the damaged shoots to rot in a short period. Control measures include mainly cleaning leaf litter and waste shoot pieces around shoot stocks, and covering the stock with sheets to prevent egg-laying by adult flies.

Culm-boring Moths (Lepidoptera: Tortricidae and Pyralidae)

Olethreutes paragramma Meyrick

DISTRIBUTION

India, Bangladesh and Pakistan.

HOST

Dendrocalamus strictus.

BIOLOGY

This moth is recorded as a common pest on standing green culms of *D. strictus.* The female moth lays eggs on the culm sheath. Young larvae feed at the sheathing

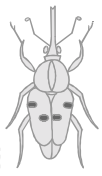


Fig. 48: Adult moth of ***Olethreutes paragramma***

bracts and subsequently tunnel down the soft stem and nodes of the growing culm. A fully grown larva is about 17 mm long with numerous black tubercles. Pupation occurs in a silken cocoon formed between the bract and the node (Beeson 1941; Browne 1968; Singh and Bhandari 1988).

DAMAGE CAUSED

Heavy infestation causes death of young culms (Fletcher 1920).

Epiparbattia gloriosalis Caradja

DISTRIBUTION

Southern China.

HOST

Sinocalamus affinis.

BIOLOGY

This moth species is a shoot/young culm borer. Larvae

burrow into shoots and young culms and bore inside. Fully fed larvae make emerging holes and remain in cocoons in the damaged stem for overwintering. Adult moths emerge and lay eggs individually on leaves in the following spring when new shoots are available.

Shoot/Culm-boring Beetles (Coleoptera: Chrysomelidae and Cerambycidae)

Bamboo Hispine Beetle - *Estigmena chinensis* Hope

DISTRIBUTION

Bangladesh, India, Malaysia and Myanmar.

HOSTS

Bambusa bambos, B. burmanica, B. nutans, Gigantochloa scortechinii, Schizostachyum pergracile and *Dendrocalamus strictus.*

Fig. 49: Adult of ***Estigmena chinensis***

BIOLOGY

The bamboo hispine beetle is an important pest of bamboo shoots and very young culms in natural stands and plantations. Attack usually occurs during the first few months of culm growth and rarely during the second year (Beeson 1941; Roonwal 1977). Adult beetles are light brown to black in colour and elongated (Roonwal 1977). There is one generation per year. Overwintering adults become active before the onset of south-west monsoon. Eggs are deposited in small groups on the surface of internodes beneath the leaf axil. Incubation period is 19-30 days. Nymphs feed first on tender tissue beneath sheaths, then bore the wall of the internodes upwards or downwards, and excavate tunnels by making tiny slit-like entrances when they are fully grown in September. After a short pupal period, adult beetles emerge but remain in the tunnels from October till the onset of the monsoon of the following year.

DAMAGE CAUSED

Damage is found mostly on solid bamboos with small-sized culms and the solid part of hollow bamboos. The damage causes bending of new culms and may even kill the bamboos in case of heavy infestation.

CONTROL

Congestion within and between clumps, as well as split culms provide the beetle with shelter during the dry, hot season. Damaged culms should be cut and exposed directly to sunlight to kill beetles inside (Beeson 1941). Keeping reasonable culm and clump density is also recommended in controlling the pest. About 15% shoots and young culms were damaged by the pest in natural stands of *Gigantochloa scortechinii* in Malaysia (Abd. Latif, pers. comm.).

Stem Beetle - *Sagra femorata purpurea* Lichtenstein

DISTRIBUTION

Southern China and Vietnam.

BIOLOGY

The stem beetle, which displays heteroecism, feeds mainly on the rattan *Pueraria lobata,* its primary host, but can attack a number of other agricultural crops and forest trees, including standing bamboos, at its late larval stage. Adults lay eggs on the stem of the rattan. Nymphs mine into the stem and bore inside. Most nymphs at their second or third instar move on to bamboo culms (or other trees) on which the rattan plant climbs, bore into the culm and feed on the inside wall of the culm. Adults, which vary markedly in length from 8 to 22 mm, are purplish-red in colour, although a few black ones can also be found. There is one generation per year, overwintering as fully grown nymphs in culm tunnels. Adults emerge in May-June. The elongated egg-mass, containing 2-6 eggs, is covered by a gelatinous layer. Larvae feed on the rattan from June to July and most of them then move on to secondary hosts until the following May.

CONTROL

Young larvae of the stem beetle cannot feed on bamboo culm and other trees; hence, the insect is only found in bamboo stands where the rattan *P. lobata* also grows. Removal of *P. lobata* plants has proven an effective method to keep bamboo plants free from the pest (Zhang Zongfu 1984).

Brown Long-horned Beetle - *Pterolophia trilineicollis* Gressitt

DISTRIBUTION

China.

BIOLOGY

Long-horned beetles feed on young, growing bamboo culms. ***Pterolophia trilineicollis*** has an annual life cycle. Adults emerge in October and remain in the tunnels bored for overwintering. Eggs are laid in groups on very young culms. Larvae occur from May to September and bore on the culm wall. Up to 50 larvae per culm were recorded during heavy attacks, causing the death of damaged culms. Adult beetles are, on an average, 12.5 mm long and 5 mm wide, and dark brown in colour.

Red Long-horned Beetle - *Purpuricenus temminckii* G.-M

DISTRIBUTION

China, Japan and Korea.

Fig. 50: Adult of ***Purpuricenus temminckii***

HOST

Both growing and felled culms of *Phyllostachys* spp.

BIOLOGY

The adult is 12-18 mm long, 4-6 mm wide and red or purplish-red in colour, with five round, black spots on the protergum. There is one generation per year, overwintering mostly as adults (some overwinter as pupae or larvae) on the culm. Eggs are laid individually on the outer layer of culm stacks or above the nodes of standing culms. Larvae hatch in May, burrow into the culm cavity and feed on culm tissue on the inner surface.

DAMAGE CAUSED

The insect is usually present in large numbers at sunny, dry sites (Huang Rizong 1963). Larvae bore tunnels on culms, causing the death of standing culms and degradation of felled culms.

4. GALL MAKERS

Gall-making Midge (Diptera: Cecidomyiidae)

Planetella conesta Jiang

DISTRIBUTION

China.

BIOLOGY

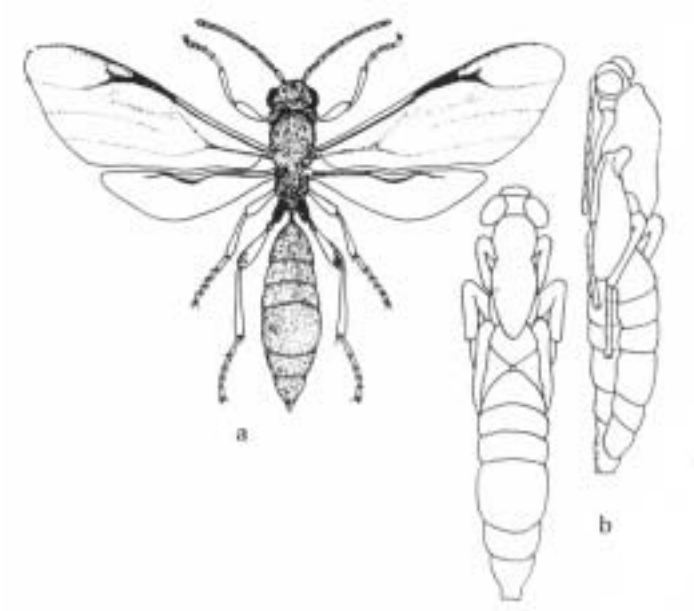
The midge, *Planetella conesta* is reported to attack bamboo leaf buds. The adult is 2.4-2.8 mm long and reddish in colour. The larva is 3.2-4.3 mm long and milk-white in colour. There is one generation per year. Adults occur in March and larvae from late March. Eggs are laid in groups on the inner surface of leaf sheaths or on the basal part of buds. Larvae mine into buds through the bud scale and remain there feeding on sap for 40-50 days, causing failure in bud development. They develop fully by July, drop to the ground and remain in cocoons in the surface layer of the soil until the following March. Rains and humid conditions favour the pest's dispersal and survival.

CONTROL

Soil-turning during summer and winter months can cause high mortality of the larvae remaining in the soil. (Cai Xiaoyang 1988).

Gall-making Chalcids (Hymenoptera: Eurytomidae and Ceraphronidae)

Aiolomorphus rhopaloides Walker



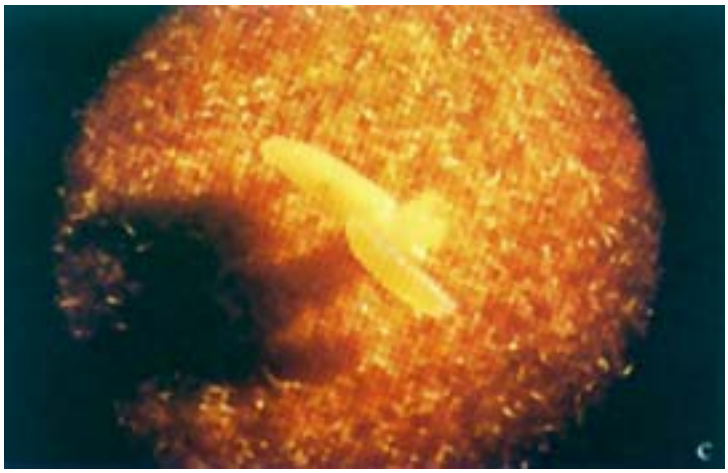


Fig. 51: Life stages of ***Aiolomorphus rhopaloides***
a: adult wasp; b: pupa; c: larva (the smaller larva is that of ***Diomorus aioromorthi***)

DISTRIBUTION

Widespread in all bamboo-growing areas in China and Japan.

HOST

Phyllostachys spp.

BIOLOGY

This is an important phytophagous chalcid pest. It forms galls at the base of young twigs and causes deforming and shedding of leaves. The adult wasp is 7-8.2 mm long, 1-1.2 mm wide and black in colour. Wings are covered with dense, short hairs. The milky white larvae, when fully grown, is 6-7.5 mm long and 1.3-1.5 mm wide. There is one generation per year, overwintering as pupae in the gall. Adults emerge from early January to February and come out from the gall in March, when leaf buds are available. Eggs are deposited inside the internode of newly-sprouted leaf buds, which, as they develop, swells at the basal part where the eggs are deposited, forming a hollow and elongated gall. Larvae feed on the inner tissue of the gall and pupate inside in September. There are five larvae instars (Anonymous 1977; Wang Haojie et al. 1996a).

DAMAGE CAUSED

The damages caused — deformation and defoliation — rarely cause the death of plants, but result in reduced growth vigour and a 30-60% fall in shoot production.

CONTROL

Chemical control of ***A. rhopaloides***, if necessary, can be achieved by culm-cavity injection of the systemic insecticide methamidophos (1.5 ml per culm) in late April to kill the very young larvae (Mo Jianchu et al. 1992).

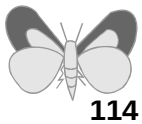


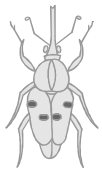
Fig. 52: Galls made by ***Aiolomorphus rhopaloides*** on *Phyllostachys pubescens* a: young galls and deformed leaves compared with healthy leaves b: matured gall

Other Gall-making Chalcids

There are several other chalcid wasp species occurring together with ***A. rhopaloides*** in bamboo stands. The interspecific relationship among them is quite complicated, although they are all probably

phytophagous. ***Diomorus aioromorthi*** Kamrjo (Hymenoptera: Torymidae), the most abundant species among them, is an important natural enemy of ***A. rhopaloides***. The torymid chalcid has an inquilinous life: it lays eggs in young galls made by ***A. rhopaloides***, the larvae developed kill the eurytomid larvae and then feed phytophagously in the gall to complete its development. The rate of parasitism ranges from 50% to 70% (Takahashi and Mizuta 1971; Wang Haojie et al. 1996b).

***Ceraphron* sp.** has been recently recorded in some newly established bamboo plantations (mostly *Bambusa bambos*) in Kerala, India (Mathew and Varma 1990). The insect lays eggs on the growing tip of the main culm or side shoots. The insects that develop inside cause swelling of the shoot, resulting in retardation of growth. These minute insects, when ready for emergence, escape through small slits formed in the middle of the swollen part of the shoot. The apical ends of the shoots that develop into galls dry up later.



5. RHIZOME AND ROOT FEEDERS

Root Fly (Diptera: Psilidae)

Chyliza bambusae Yang et Wang

DISTRIBUTION

China.

HOST

Phyllostachys pubescens.

BIOLOGY

Chyliza bambusae has one generation per year, overwintering as pupae in the soil. However, in stands of *Phyllostachys pubescens* with alternating 'on' and 'off' years of shooting, some pupae diapause until the following 'on' year of shooting. Adult flies emerge in early spring when the daily mean temperature reaches 12^{o}C and bamboo shoots are about 10 cm in height. Adults prefer to feed on bamboo shoot sap. Female adults burrow along bamboo shoots into the soil, and deposit eggs individually in the soil at 2-6 cm deep around young shoots' root system. Larvae hatch in 3-10 days and very young larvae feed on root tips. The older ones mine into the root and tunnel inside for feeding. The larvae are fully fed by late May, passing through three instars, and make pupal chambers at the end of the tunnel.

DAMAGE CAUSED

The fly attacks roots of very young plants. Damaged roots, being much shorter and with reduced absorbing function, cause shoots dry out or develop into culms which are weak and susceptible to collapse in wind.

CONTROL

Turning earth around bamboo shoots soon after shooting can prevent the female flies from reaching egg-laying sites. Another practical measure against the pest is to use insecticide-ingested shoot pieces placed in bamboo stands to bait adult flies before egg-laying (Yang Jikun and Wang Xinle 1988; Xu Tiansen and Lu Ruoqing 1988).

Root Beetles (Coleoptera: Elateridae)

Several species of root beetles, including ***Agonischius obscuripes*** Cyllenbal, ***Agriotes* sp**., ***Lacon* sp**. and ***Melanotus regalis*** Candeze, have been identified as pest insects on various bamboo species in China. Damages are caused by the larvae feeding on young roots of new shoots, causing the death of shoots, or the development of weak culms susceptible to collapse in wind. Soil treatment with insecticides, in combination with earth-turning and soil-loosening after harvest of edible shoots, can be employed to control these pests.

Bamboo Cicadas (Homoptera: Cicadidae)

Bamboo cicadas include ***Platylomia pieli*** Kato, ***Huechys sanguinea*** De Geer and ***Mogannia hebes*** Walker. The nymphs of these large, winged cicadas feed on underground rhizomes and root system. They have very similar life histories and damaging habits.

Platylomia pieli Kato

DISTRIBUTION

Widespread in all bamboo growing areas in China.

HOST

Mainly *Phyllostachys* species.

BIOLOGY

Adults are 40-46 mm long and are densely covered with golden hair. There is a light brown or dark green, narrow marking on the protergum of the adult. The insect takes several years to complete one generation and overwinters as eggs and nymphs. Adults emerge in summer months and feed on saps from trees in or around bamboo stands. Eggs are laid in holes made in line on small branches of bamboo plants and take about 11 months to hatch. Nymphs that hatch drop to the ground during rainfall or wind and burrow into the soil. They suck sap from rhizomes and roots throughout the year and take several years to develop fully, passing through five instars.

DAMAGE CAUSED

Damages caused weakens the underground rhizome and root systems, and induces failure in the development of new rhizomes and shoots, thus significantly reducing the productivity of bamboo stands.

CONTROL

Branches with eggs die from egg-laying wounds and hence, can be identified easily. Removal of such branches is considered the most effective way to keep bamboo cicadas at a low level of population (Gan Zhongnan 1984).

Termites (Isoptera: Rhinotermitidae and Termitidae)

The incidence and extent of damage caused by termites to standing bamboo culms is generally negligible.

Fig. 53: Damage caused by termites

Usually, they feed only on dying and dead culms; however, the termites feeding around bamboo culms cause new culms to originate higher up, ultimately resulting in congested culm growth (Beeson 1941; Roonwal 1979; Thakur 1988a).

Species of termites recorded to damage bamboos are ***Ceylonitermes indicola*** Thakur (damages roots of bamboos in Kerala, India), ***Coptotermes heimi*** Wasm., ***Pseudocapritermes goanicus*** Thakur et Chatterjee (damages bamboo clumps in Goa, India), ***Microcerotermes fletcheri*** Holmg. et Holmg., ***M. heimi*** Wasm. and ***M. obesi*** Holmg. (found attacking green clumps of bamboos in peninsular India).

Since damage caused by termites to bamboo culms is negligible, specific control measures are not required.

White Grubs - Holotrichia sp. (Coleoptera: Scarabaeidae)

The white grub species, ***Holotrichia* sp.**, has been reported as a minor pest attacking young rhizomes of *Bambusa bambos, B. nutans* and *Dendrocalamus strictus* in India (Meshram et al. 1989). The beetles lay eggs in sandy soil after the first monsoon rains. Hatching takes place after seven days. The freshly hatched grub is creamy white, C-shaped and about 4.5 mm in length. The grub feeds on the roots and rhizomes of bamboos in nurseries and plantations. Pupation occurs in earthen cocoon in soil during September-October. After a pupal period of eleven days, the adult beetle emerges, but does not come out from the soil till the pre-monsoon rains.

The damage caused in general is not very serious and hence no control measures are suggested.

Fig. 54: Adult of ***Holotrichia* sp.**

Long-horned Beetles (Coleoptera: Cerambycidae)

Dorysthenes walkeri Waterhouse

DISTRIBUTION

China, India and Myanmar.

BIOLOGY

The beetle is primarily a pest insect on sugar-cane, but also feeds on bamboos, and coconut and oil palms. Adults occur from May to September and lay eggs in the soil at 2-3 cm depth. Larvae mine into roots and bore inside. Fully fed larvae come out of the bored tunnels and make new tunnels in the soil at 20-25 cm depth for pupation. The adult beetle is 37-65 mm long, 14-27 mm wide and varies from dark brown to black in colour (Chien Tingyu 1982).

D. buqueti is recorded as a pest on bamboos in China, India, Indonesia, Laos, Malaysia, Myanmar and Nepal, and causes damages similar to ***D. walkeri***.

6. SEED PESTS

Seed Bugs (Heteroptera: Pentatomidae)

Udonga montana Distant

Fig. 55: Adult of ***Udonga montana***

DISTRIBUTION

India, Bangladesh and Myanmar.

HOSTS

Bambusa polymorpha, Dendrocalamus strictus and *Melocanna baccifera.*

BIOLOGY

Adults of the bamboo seed bug are ochreous yellow in colour. Eggs are laid in groups on flower heads.

Nymphs which hatch out are black in colour and measure about 2 mm in size. The attack on bamboos normally occurs when they are in flower. After the cessation of flowering season, the insect population generally declines, because of lack of food or other adverse environmental factors.

DAMAGE CAUSED

Both adult bugs and nymphs suck sap from bamboo seeds, causing the seed production in natural stands to be affected. Seeds are eaten away during the formative stages and also after they have fallen on to the ground. This is a serious pest of bamboo seeds and sporadic outbreaks has been reported by many authors (Garthweite 1938; Beeson 1941; Mathew and Sudheendrakumar 1992).

CONTROL

Predation by birds is a natural way of control. Foliar spray of 0.25% fenitrothion or endosulphan has also been recommended.

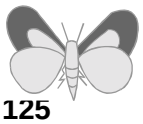
Grain Moths (Lepidoptera: Gelechiidae)

The grain moth, ***Sitotroga cereallela*** Oliver, is generally a pest of stored grains. It is a serious pest of stored seeds of bamboos. On infestation, there is one larva per seed, and the life-cycle is completed within the seed (Beeson 1941). Eggs of the pest are often parasitized by *Trichogramma evanescens*. Fumigating seeds with carbon disulphide is recommended. Methyl bromide can also be used, but it is an ozone depleting chemical, the use of which is being phased out. Hundred kilograms of seeds can be fumigated with 2-3 ml of fumigant.

7. NURSERY PESTS

Only limited information is available on the intensity of damage caused by insect pests in bamboo nurseries.

A few termites belonging to the genus ***Odontotermes*** are reported to cause injury to the root system of *Bambusa tulda* (Thakur 1988b). The fibrous roots are eaten away leading to the drying up of young seedlings. White grubs belonging to the genus ***Holotrichia*** are reported to cause damage to *Dendrocalamus strictus,* often leading to the death of seedlings. Some of the grasshoppers, such as ***Hieroglyphus banian*** Fab. (Beeson 1941) and ***Poecilocerus pictus*** Fab. (Browne 1968), have been reported to cause minor injury and subsequent defoliation in India and Pakistan. The bamboo leaf roller, ***Algedonia coclesalis*** Walker, is found to feed on seedlings of various bamboo species in China. No routine measures are practised against the above pests, as the damage caused is negligible.



8. POST-HARVEST PESTS

About 50 insect pests have been reported to attack felled culms and products made of bamboo timber. They are all borers, and the important species are mainly from the families of Cerambycidae, Bostrychidae and Lyctidae.

Shot-hole Borers (Coleoptera: Bostrychidae)

There are about 16 bostrychid species attacking post-harvest bamboos in Asia. The most important species are all from the genus ***Dinoderus*** and include ***D. japonicus*** Lesne, ***Dinoderus minutus*** Fab., ***D. ocellaris*** Stephens and ***D. brevis*** Horn. They are responsible for over 90% of insect damages on harvested culms and finished bamboo products. These species have very similar life histories and damaging habits. Both adults and larvae feed inside felled culms, but the latter causes the major damage. Adults burrow through wounds or cut ends into the culm and make horizontal tunnels around culms, where eggs are deposited. Larvae bore longitudinally in the culm. Heavy infestation results in numerous criss-crossing tunnels which are tightly filled with excreta. The fully developed larvae make chambers in which they pupate. Adults emerge out through the external rind just above their pupal chambers.

Japanese Shot-hole Borer - *Dinoderus japonicus* Lesne

DISTRIBUTION

Widespread in almost all bamboo-growing countries.

HOSTS

Phyllostachys species, mostly *P. viridis,* and *Pleioblastus* species.

BIOLOGY

The adult beetle is 3.5-5 mm long, dark brown in colour and covered with dense punctums and brown hair. The borer mostly has an annual life cycle and overwinters as adults. Individuals vary significantly in development rate. A small portion of adults emerge in July and produce the second but incomplete generation which overwinters as larvae. Adults emerging after July remain in the tunnel until the following April. The adult stage lasts from July to the following June, and larvae feed in culms from May to August. Adults have obvious preference in selection of egg-laying sites. *Phyllostachys viridis* is most favoured and *P. pubescens* and *Pleioblastus amarus* are free from attack when culms of the three species are stacked together. However, if *P. viridis* is not available, others are infested. They prefer newly-felled culms and basal, which has the highest market value (Liu Jinying 1956; Chang Lefeng et al. 1979).

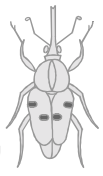
Ghoon Borer - *Dinoderus minutus* Fabricius

DISTRIBUTION

China and most South Asian countries.

HOSTS

Bambusa bambos, B. polymorpha, B. textilis, B. vulgaris, Dendrocalamus giganteus, D. hamiltonii, D. strictus, Phyllostachys pervariabilis, P. pubescens.



BIOLOGY

This beetle is probably the most destructive and widespread insect pest on felled culms and finished bamboo products. The adult is about 3 mm long, reddish or dark brown in colour and covered with dense punctums and hair which are more obvious on the rear end of the wings. There are three generations in China and 3-4 generations in South Asian countries per year, but the generations are heavily overlapped. Adults and larvae can be found at any given time of the year and overwintering is not distinct, although they are less active in cold winter. Eggs, laid individually

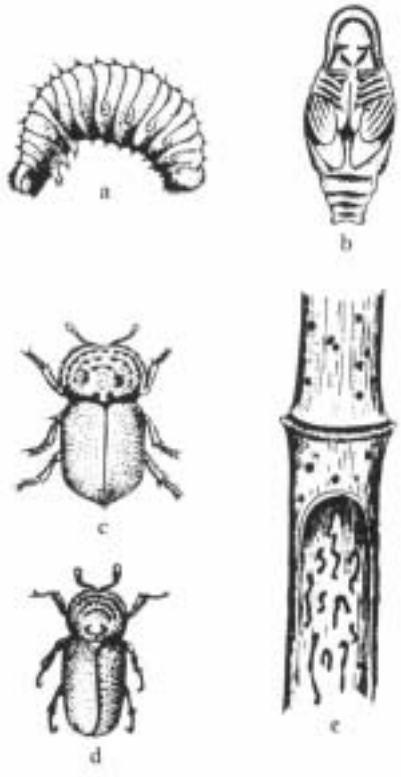


Fig. 56: Ghoon borers a: larva of ***Dinoderus minutus****;* b: pupa; c: adult; d: adult of ***Dinoderus ocellaris*** e: damage symptom showing beetle holes and galleries (Courtesy: Indian Forester, No. 10, 1988*)*

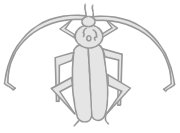
in tunnels mined by adults, hatch in 5-8 days. Larvae bore longitudinally in the culm and take about 40 days to develop. Pupation occurs in cocoons made at the terminal end of larval tunnels. The newly developed adult beetles may fly away or may explore other parts of the same bamboo.

DAMAGE CAUSED

Adult beetles burrow into felled culms through wounds, cracks and cut ends, and make horizontal tunnels along the fibrovascular tissues of the culm; larvae make longitudinal tunnels. The beetle shows strong preference to newly-felled culms of some species, while others — such as *Pseudosasa amabilis* and *Pleioblastus* species — are hardly ever attacked. Culms from level sites are more susceptible to attack than those felled from sloping sites. A large population of the borer will leave numerous tunnels in the culm, making it useless.

CONTROL

A chequered beetle (Coleoptera: Cleiridae) preys on the borer in the boring tunnels (Liu Yun and Xu FM 1982; Tan Zhongyi 1984; Wu Jianfen Huang Zenghe 1986). ***D. minutus***, and ***D. brevis*** and ***D. ocellaris*** (two other major borers reported in South Asia as major pests of bamboos in storage), are parasitized by *Spathius bisignatus* Walkn. and *S. vulnificus* Walkn. (Hymenoptera: Braconidae). The larvae, pupae and beetles are preyed upon also by *Tillus notatus* Kulg. and *T. succinatus* Spin (Coleoptera: Cucujidae) (Beeson 1941; Chatterjee and Mishra 1974). These natural enemies cannot be relied upon as an effective control method, although they can cause high mortality of the borers.



Starch, soluble carbohydrates and proteins are nutritionally essential to these shot-hole and powder-

Fig. 57a,b: Damage caused by ***Dinoderus minutus***

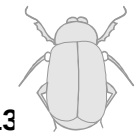
post beetles. The incidence of borer attacks has a strong correlation to the richness of nutrients in felled culms, and vary significantly with bamboo species, growing sites, timing and culm age at felling, and the method of transportation and storage. In general, culms felled

at young age and growing season, and those growing on shaded, wet sites are more susceptible to attack by these borers.

Some preventive and preservative measures have been developed against these borers. The timing and age of felling are very important. Culms will have less soluble carbohydrates, proteins and moisture as they get older, and they are less active physiologically in winter season and thus more resistant to the timber borers. Hence, harvesting only culms over 3-4 years old and felling at winter season are particularly recommended.

After felling, treating culms physically or chemically can significantly improve their resistance to borers as well as to fungus. The traditional and most simple method is to immerse felled culms in water. This method may be effective only in preventing damages from bostrychid beetles. It is also suitable only for those bamboos with a low starch content (Sulthoni 1990), takes a long time, and culms treated in this way tend to blacken (Xu Tiansen 1983). Heating of culms by fire or boiling water, or putting them under direct sunlight in hot summer can kill borers in the culms. Some advanced microwave and infrared techniques have been developed recently for killing the borers in bamboo culms (Yao Kang et al. 1986).

Chemical treatment using various insecticides and preservatives have been the most widely used method in controlling post-harvest pests of bamboos. Various preservatives have been recommended and used in different countries: 5% water solution of copper-chrome-arsenic composition (CCA); 5-6% water solution of copper-potassium dichromate-borax (CCB); 5-6% water solution of boric acid-borax-



sodium pentachlorophenate in 0.8:1:1 or 1:1:5 ratio (BBP); 2-3% water solution of borax:boric acid in 5:1 ratio; and 10% or 20-25% water solution of copper sulphate. These are mostly applied by soaking under normal temperature, cold or heated conditions, or under high pressure (Singh and Tewari 1979, 1981a,b; Nair et al. 1983; Xu Tiansen 1983; Liu Yun and Xu FM 1985; Zhou Fanchun 1985; Kumar et al. 1985; Thapa et al. 1992).

Bamboo rind and similar semi-finished products can be treated by soaking in an aqueous solution of 2% boric acid, 0.5% pentachlorophenate and 5% alcohol. Sulthoni (1990) reported treating dried bamboo splits by immersing them in diesel oil as a simple and cheap method of bamboo preservation. Some insecticides have also been tested and used. Varma et al. (1988) tested the effectiveness of several commercial formulations of insecticides against ***Dinoderus minutus*** and ***D. ocellaris***, and concluded that BHC and two pyrethroids — cypermethrin and permethrin — were effective. Mori and Hideo (1979), through a screening test, reported that two low-toxicity organophosphorus insecticides — prothiophos and phoxim — were more effective than organochlorine ones for preservation of bamboo materials against fungi and boring pests. Treating culm splits by immersing them in 0.2% phoxim for three minutes can result in the total mortality of ***D. minutus*** in the culm in 2-3 days, and can protect the treated split free from attack for over one year (Zhou Huiming et al. 1987). Soaking of culms in a weak water solution of methamidophos for 8 hours is recommended for controlling ***D. japonicus*** (Chang Lefeng et al. 1979). Affected bamboo material can also be treated by fumigating in closed chamber or storehouse with sulphuryl fluoride at the rate of 30-50 g/m^3 of timber for 24 hours.