INSECT PESTS of BAMBOOS in ASIA

An Illustrated Manual

Wang Haojie
Research Institute of Subtropical Forestry
Chinese Academy of Forestry
Fuyang, Zhejiang, China

R.V. Varma
Kerala Forest Research Institute
Peechi, Kerala, India

Xu Tiansen
Research Institute of Subtropical Forestry
Chinese Academy of Forestry
Fuyang, Zhejiang, China

International Network for Bamboo and Rattan
Beijing ■ Eindhoven ■ New Delhi

The International Network for Bamboo and Rattan (INBAR) develops, provides and promotes appropriate technologies and other solutions to benefit people and the environment. A world-wide network, it connects governmental and non-governmental organizations and the private sector. INBAR provides leadership, coordination and support for research and development. INBAR's R&D programs cover natural and cultivated raw materials; genetic resources, processing and utilization; economic and other social aspects; and supporting services. INBAR aims to enhance the quality of life of poor and disadvantaged people in developing countries and to make favourable impacts on forests and degraded environments.

International Network for Bamboo and Rattan
c/o International Development Research Centre
17 Jor Bagh
New Delhi 110 003
INDIA

ISBN 81-86247-23-8

Design & Production
Art Options, New Delhi

FOREWORD

Bamboos are an integral part of the civilization and tradition in almost all Asian countries. These hardy woody plants with their multifarious uses are mostly harvested from natural forests or village groves. In modern times, however, the pressures exerted by burgeoning populations and expanding industries such as rayon, pulp and paper, have placed considerable stress on the resource base. In response to this, and realizing the immense potential of bamboos, many nations have started facilitating and encouraging the establishment of large-scale bamboo plantations.

Insects have been very much a part of bamboo eco-systems, with over 800 species of them identified as bamboo pests. While natural forest systems have a way of keeping pest populations under control, man-made plantations require human intervention to ensure their survival and productivity. As bamboos are now being grown increasingly and intensively in plantations, the need for a better understanding of and an increased vigilance against pests has become essential and urgent.

The International Network for Bamboo and Rattan (INBAR) has been aware of this, and considering the extreme paucity of information on insect pests of bamboos in Asia, it made the decision to fund, through the award of an internship, a project that would review these. The project was jointly undertaken by the CAF Research Institute of Subtropical Forestry (RISF), China, and the Kerala Forest Research Institute (KFRI), India. This publication *Insect Pests of Bamboos in Asia* is a result of the project.

Extensive literature collection, review and field visits have been undertaken by Wang Haojie and Xu Tiansen of RISF and R.V. Varma of KFRI to prepare an extensive account on the insect pests of bamboos in Asia, to serve as a knowledge base for combating the pests. Several of their peers from different parts of Asia whole-heartedly cooperated in this project. We are delighted to bring out this manual as a testimony to the professional enthusiasm of these scientists and to the effectiveness of networking among scientists.

We hope that this publication will mark the beginning of renewed research in the field, particularly on a more exhaustive identification and classification of insect pests and in assessing their impact on bamboo-based economies.

I.V. Ramanuja Rao
Principal Scientist
& Secretary to the INBAR Board

Cherla B. Sastry
Director General

CONTENTS

FOREWORD 3

THE IMPACT OF BAMBOO PESTS ON THE ECONOMY 8

INTRODUCTION 14

1 DEFOLIATORS 18
Locusts 18
Leaf Rollers 25
Puss Moths 36
Tussock Moths 42
Leaf Skeletonizer Moths 46
Slug Moths 50
Noctuid Moths 52
Tent Caterpillar Moths 53
Leaf Miners 55
Satyr Butterflies 57
Common Skippers 61
Leaf Beetles 63
Sawfly 64

2 SAP SUCKERS 66
Stink Bugs 66
Lygaeid Bugs 69
Mirid Bugs 70
Coreid Bugs 71
Froghoppers 73
Planthoppers and Leafhoppers 75
Aphids 76
Pseudococcid Scale Insects 79
Pit Scale Insects 82
Armoured Scale Insects 84
White Flies 87
Leaf Mites 88
Thrips 89

3 SHOOT AND CULM BORERS 91
Bamboo Shoot Weevils 91
Shoot-boring Noctuids 98
Shoot Flies 102
Culm-boring Moths 105
Shoot/Culm-boring Beetles 107

4 GALL MAKERS 112
Gall-making Midge 112
Gall-making Chalcids 113
Other Gall-making Chalcids 115

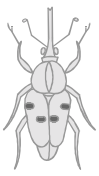
5 RHIZOME AND ROOT FEEDERS 117
Root Fly 117
Root Beetles 118
Bamboo Cicadas 118
Termites 119
White Grubs 121
Long-horned Beetles 122

6 SEED PESTS 123
Seed Bugs 123
Grain Moths 124

7 NURSERY PESTS 125

8 POST-HARVEST PESTS 126
Shot-hole Borers 126
Powder-post Beetles 133
Long-horned Beetles 136
Termites 139

9 INTEGRATED INSECT PEST MANAGEMENT 141
Silvicultural Control 141
Direct Control 142
Biological Control 144
Chemical Control 145
Management of Post-harvest Pests 147



10 ENTOMOLOGICAL RESEARCH ON BAMBOO IN ASIA 149
Research Activities and Achievements 149
Major Existing Problems 151
Recommendations for Future Research 152

ACKNOWLEDGEMENTS 155

REFERENCES 157

GLOSSARY 177

APPENDIX 179
Check List of Pests and Hosts 179

INDICES 195
Index of Pests 195
Index of Hosts 200

THE IMPACT OF BAMBOO PESTS ON THE ECONOMY

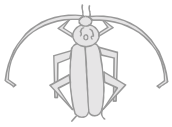
Insect pests are believed to cause considerable losses to bamboo in natural stands and plantations, and some of these are very obvious. However, owing to the absence of reliable quantitative data, very few assessments have been made on their economic impact.

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 and epidemics can cause severe or 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. The extent of leaf consumption by some major bamboo leaf feeders was measured in some studies (Xu Tiansen 1984a, 1985b; Xu Tiansen and Lu Ruoqing 1978b, 1990, 1991). The results are summarized in Tables 1 and 2.

A large number of insects, which have highly modified piercing-sucking mouthparts, feed on the sap of leaves,

Table 1: Leaf consumption by the bamboo locust ***Ceracris kiangsu***

Measurement method	Sex	Nymph instars 1st	2nd	3rd	4th	5th	Adult stage	Total
Leaf area	Male	8.84	19.59	39.96	67.87	124.29	413.99	671.54
(cm^2/insect)	Female	12.68	26.39	48.18	98.16	185.94	818.82	1190.17
Dry weight	Male	35.60	78.80	149.70	273.10	500.20	1655.90	2702.80
(mg/insect)	Female	51.00	106.20	193.90	387.00	748.30	3295.10	4781.70



branches, culms, shoots, roots and rhizomes. These insects can damage bamboo in four ways: (1) removing the plant fluid; (2) causing mechanical

Table 2: Mean leaf consumption (in cm^2) per defoliating larva on *Phyllostachys pubescens*

Insect Species	Generation	Larval instars								Total
		1	2	3	4	5	6	7	8	
Bamboo leaf roller										
Algedonia coclesalis	1	0.11	0.29	0.75	1.52	4.34	9.26	32.63	67.95	116.85
Bamboo puss moths										
Loudonta dispar	1	-	1.22	4.43	13.96	49.60	358.16	-	-	427.37
	2	-	1.28	3.48	12.56	47.78	333.90	-	-	399.00
	3	-	0.92	2.71	8.70	33.38	262.78	-	-	308.47
	4	-	1.05	1.90	6.67	26.59	95.76	-	-	131.97
Besaia goddrica										455.83
Stenadonta radialia	1	-	-	-	-	-	-	-	-	155.51
Mimopydna insignis	1	-	-	-	-	-	-	-	-	630.53
Norraca retrofusca	1	-	-	-	-	-	-	-	-	661.41
Bamboo tussock moth										
Pantana sinica	1	-	1.24	1.82	4.47	9.20	18.92	50.71	81.43	167.79
Bamboo slug moth										
Parasa bicolor	1	0.34	1.01	2.55	6.28	17.34	61.24	111.36	218.28	418.43
Bamboo satyr butterfly										
Neope muirheadi	1	1.25	3.32	12.06	37.82	241.88	-	-	-	296.33

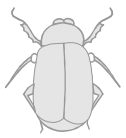
injury from egg-laying; (3) injecting toxic compounds into the plant; and (4) transmitting diseases. The results are defoliation, wilting of young shoots and branches, and even death of the culm. During a heavy outbreak of the leaf mites ***Schizotetranychus* spp.** in central China in 1989, an average of 85.2 mites per leaf were recorded. The damage resulted in the reduction of new shoot production by 200 kg per hectare in the following year (Yu Huaxing and Shi Jimao 1991). Fei Xueqing et al. (1990) reported the metabolism disorder in *Phyllostachys pubescens* caused by the bamboo stink bug ***Hippotiscus dorsalis*** (Table 3). The aphid ***Oregama bambusae*** sucks the sap of growing shoots of bamboos (Singh and Shivaramakrishnan 1976). Heavy infestation results in the withering of young shoots, which ultimately die.

Table 3: Nutrient content in *Phyllostachys pubescens* damaged by ***Hippotiscus dorsalis***

Nutrients	Condition of bamboo			
	healthy	light damage	medium damage	heavy damage
Soluble sugar (%)	1.50	1.29	1.04	1.04
Total sugar (%)	3.84	3.53	2.88	2.83
Total free amino acids (mg/100 g)	39.90	75.72	178.26	307.07

Compared to defoliators and sap suckers, culm and shoot borers have less effect on the plant physiology. But these can greatly reduce culm and shoot yields and are considered to be of major economic importance. A single larva of a culm borer can destroy a culm. The attack of the borer ***Cyrtotrachelus* spp.** is positively correlated with the density of the culms. The hispine beetle ***Estigmena chinensis*** is another pest capable of culm destruction. The damage occurs in solid bamboos of smaller thickness and solid parts of thick-walled hollow bamboos. The attack is severe only during the first few months of the culm growth (Beeson 1941; Roonwal 1977). The attack by ***E. chinensis*** is also reported to cause bending of bamboos. Singh (1990), in a study on the status of pest problems in India, showed that at least 25% of the standing culms of *Dendrocalamus strictus* are damaged by stem-boring beetles.

The shoot borer is also regarded a major problem, causing widespread damage to bamboo culms in Bangladesh and Nepal. In Nepal, an estimated 10% of new shoots are damaged every year by shoot borers.



Galls, induced mainly by chalcid wasp species, are common sights on bamboo twigs. Galls cause abnormal growth and shedding of leaves on the affected twigs and thus, probably, affect photosynthesis. The

impact of galls on the productivity of bamboo stands, however, remains to be evaluated.

Seed pests, which affect seed production, may have some impact on the establishment of new plantations. Mass build-up of the bug ***Udonga montana*** on natural bamboo stands is an occasional occurrence (Singh and Bhandari 1988; Mathew and Sudheendrakumar 1992). The bugs feed on developing bamboo seeds, thereby destroying the means for natural reproduction.

Bamboo under storage, either as culms or as finished products, is very susceptible to damage by insects. Occasionally, subterranean termites cause severe damage. However, the most important pest of bamboo under storage conditions is the ghoon borer or the powder-post beetles ***Dinoderus*** **spp.** Large quantities of culms are destroyed each year by borer insects, although the extent of loss has not yet been assessed. In the storage yards, stacks with immature culms become the starting point of attack and the bamboo is often converted to dust. About 40% of the bamboo stack may be lost within a period of 8-10 months because of ghoon borer (Thapa et al. 1992).

Studies conducted by Nair et al. (1983) showed that the beetle infestation in storage yards is highly unpredictable and the borer incidence is apparently not related to season, but to the quality of bamboo. Earlier, it had been reported that bamboo floated in rivers remain reasonably free of insect attacks. This is probably due to the leaching out of certain soluble substances, such as sugars, favoured as food by the insects.

Mathew and Nair (1990) have reported that finished products made of reed or bamboo — such as mats, baskets, curtains, etc. — are also damaged by the

powder-post beetle ***Dinoderus minutus***, but no data is available on the extent of loss suffered.

Cryptotermes dudleyi, an introduced termite species with restricted distribution in some coastal areas of India and Bangladesh, has been reported to destroy bamboo structures in houses. The damage is often serious as the affected material is completely destroyed in a short period of time (Thakur 1988a).

It can be safely assumed that, regardless of their nature, the damage caused by pests to standing bamboos results in reduced productivity of the stands and diminished economic returns. Zhejiang Province in China offers a representative case. The Province has approximately 600 000 ha of bamboo, accounting for about one-sixth of the total area under bamboo in China. Bamboo industry in the Province, which provides more than one-fourth of bamboo timber and edible shoots produced in the country, plays a very important role in improving the living standards of the people.

The Province has some serious problems with insect pests, which strike almost every year. Most important pests are bamboo leaf rollers, puss moths, tussock moths, stink bugs, shoot-boring noctuids and bamboo shoot weevils. The lepidoptorian leaf feeders and the stink bug reach epidemic levels at intervals of 5-8 years, while the pests that affect the shoots remain at a stable population level. Yang Guorong (1991) investigated the impact of some major pests on the productivity of bamboo stands in China, indicating that the economic losses occur mainly from the death of bamboo plants, reduction in the diameter of new culms and lessened yield of edible shoots (Table 4).

Bamboo shoot weevils and shoot-boring noctuids occur in about 80 000 ha of bamboo plantations in China,

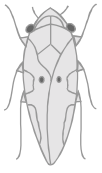
and cause the loss of about 285 000 and 8 990 tons of bamboo culms and edible shoots, respectively, every year. On an average, bamboo plantations loose about 10% of their potential turnover because of insect pest infestations.

The account given above indicates the threat some insect pests pose to the bamboo industry. It also indicates that assessments, if and when made, would undoubtedly show substantial economic losses owing to insect pests.

Table 4: Impact of major insect pests on the productivity of *Phyllostachys pubescens* stands

Insect species	Degree of damage	Insect density*	No. of dead culms (culms/ha)	Reduction in new culm DBH (%)	Total reduction in culm yield (kg/ha)	Reduction in edible (kg/ha)	Shoot yield (%)
Bamboo leaf roller	Light	< 200	12.0	2.53	583.5	195.0	9.58
Algedonia coclesalis	Medium	200-400	73.5	10.13	2269.5	420.0	20.63
	Heavy	> 400	202.5	21.52	4049.0	925.5	45.47
Bamboo stink bug	Light	< 4	45.0	3.88	871.5	246.0	12.46
Hippotiscus dorsalis	Medium	5-15	184.5	12.85	3830.5	685.5	34.73
	Heavy	> 15	633.0	35.49	11444.5	1144.5	57.98
Shoot boring noctuid	Light	5-15	0.0	0.00	1110.0	94.5	8.13
Oligia vulgaris	Medium	16-25	0.0	0.00	5975.0	493.5	42.75
	Heavy	> 25	0.0	0.00	16818.0	748.5	64.87
Bamboo shoot weevil	Light	5-15	0.0	0.00	1080.0		
Otidognathus davidis	Medium	16-25	0.0	0.00	2715.0		
	Heavy	> 25	0.0	0.00	4815.0		

* Number of insects per plant for bamboo leaf roller and stink bug, percentage of damaged shoots for others.



INTRODUCTION

Bamboo is an important forest resource in many countries of Asia. Over 1 200 bamboo species, belonging to 75 genera, are reported to occur in the world. As overexploitation rapidly depletes bamboo along with other forest resources, bamboo cultivation has received increasing attention in many countries and from various international organizations for ecological, economic and social reasons. In Asia, the major bamboo-growing area in the world, bamboo industry is closely related to people's daily lives and has an important role in national economies.

Bamboos are subject to injury by various kinds of herbivorous insects. They feed on foliage, bore holes on shoots, culm and finished products, or suck sap from the tissues of different plant organs. Attack by these insects reduces plant vigour and the productivity of bamboo stands.

Insect pests on bamboos have generally received little attention in Asian countries. In natural bamboo stands with reasonable biodiversity and stable population, insect attacks are not considered serious because various natural enemies of these insects play a useful role in the control of their populations. In addition, although some pest insects, especially the shoot borers, keep relatively high population levels and sometimes break out in natural stands, the damage caused tends to be ignored because such stands often are of low economic value. However, human intervention can have profound effects on the ecological balance and the population dynamics of insects in bamboo forest ecosystems, as in the case of some silvicultural measures for increasing the productivity of bamboos

which also favour the survival and growth or herbivorous insects. For example, the establishment of large-scale pure bamboo plantations will improve breeding conditions of insect pests, and the use of chemical insecticides will weaken the role of natural predators of these insects.

More than 800 insect species have been recorded on bamboos in Asian countries, but the threat these pose to the bamboo industry has been recognized only in a few countries. In China, where about 400 species of bamboos are grown in an area exceeding three million hectares, 683 insect species have been reported as attacking bamboos (Chang Yuzhen 1986; Xu Tiansen et al. 1993). About 60 of them break out regularly or occasionally, infesting from tens to thousands of bamboo stands in each case and causing considerable economic losses to the Chinese bamboo industry.

Although nearly 180 insect species are reported to be associated with bamboos in India (Beeson 1941; Bhasin et al. 1958; Chatterjee and Sebastian 1964; Singh and Bhandari 1988; Mathew and Nair 1990; Mathew and Varma 1990; Roonwal 1977; Singh 1990; Thakur 1988a,b; Tewari 1992), the pest status of many species is not known.

Of the approximately 80 pest insect species recorded on bamboos in Japan, the most common and important pests would probably be the bamboo leaf rollers (Nakahara and Kobayashi 1963) and the shoot-boring noctuids which sometimes attacks over 50% of the new shoots (Kaneko 1959).

Very limited information on bamboo insect problems is available from other Asian countries. There are a few references reporting shoot borers and sap-suckers

in Thailand (Choldumrongkul 1994) and Nepal (Stapleton 1985) and leaf rollers in Korea (Kim and Lee 1986). Dayan (1990) reported the results of survey on pests and diseases of bamboo in the Philippines, noting three insect pests.

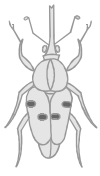
Insects that cause damage to felled culm and finished products are probably the most common and serious pests for the Asian bamboo industry. Over 50 such insect species have been reported, and maximum damage is caused by ghoon borers (***Dinoderus* spp.**) found in most Asian countries. The damages usually result in the loss of large amounts of raw materials or in the destruction of finished bamboo products.

The International Network for Bamboo and Rattan (INBAR) has been well aware of the possibility of insect pest problems becoming more significant when bamboos are cultivated intensively to meet the growing demand. Consequently, it made the decision to fund a project that would review the insect pests on bamboos in Asia, a project jointly undertaken by the CAF Research Institute of Subtropical Forestry, China, and the Kerala Forest Research Institute, India. This publication *Insect Pests of Bamboos in Asia* is a result of the project.

The main objective of this manual — prepared after extensive literature collection, review and field visits — is to provide a comprehensive account of existing knowledge on insect pests of bamboos in Asia, so as to form a knowledge base for combating the pests. Insect pests described in the text are grouped according to their feeding habits and the parts of bamboo plants they affect, except in the case of pests that attack felled culms and finished products which are grouped together. Details on hosts, distribution, biology and control measures of important pests are provided, so

that they can be identified and appropriate control methods can be selected. Basic approaches of integrated management of bamboo insect pests, the major constraints faced and the research areas to be strengthened in the future are also discussed.

One word of caution. While describing the biologies of various insect pests, the authors have used time-specific statements such as “Adults emerge in July and remain in tunnels till the following June” or “Eggs are laid in August, and larvae emerge in September”, etc. Although such information is important in understanding the biology of the insects, they may not apply equally to all Asian countries because of seasonal variations that exist from country to country.



1. DEFOLIATORS

Locusts (Orthoptera: Acrididae)

Locust is one of the most important pest insect groups that affect bamboo. Some 34 locust species have been reported that attack bamboos in Asian countries. They are classified into a number of genera, of which ***Ceracris*** and ***Hieroglyphus*** are the most common. Both adults and nymphs feed on bamboo leaves and outbreaks usually cause complete defoliation of bamboo stands. Heavy and repeated defoliation will result in the death of bamboo plants.

Yellow-spined bamboo locust - *Ceracris kiangsu* Tsai

DISTRIBUTION

Throughout the bamboo-growing areas in China.

HOSTS

Various monopodial and sympodial bamboos, as well as some agricultural crops; but prefers *Phyllostachys pubescens*.

BIOLOGY

The adult locust is about 30-40 mm long, green in colour, with a yellowish stripe from the vertex to the protergum. There is one generation per year overwintering as eggs in the soil. Nymphs hatch in May-June and take 46-69 days to develop fully, passing through five instars, to become adults during June-October. They gather on small bamboo plants for feeding and move on to bigger plants at the second instar stage. Nymphs feed in groups on leaves, starting

from the top crown and moving downwards. Adults keep feeding for about 40 days before laying eggs. Eggs are laid in capsules, each containing about 20 eggs, in the soil at 3-4 cm depth. Both nymphs and adults are attracted to uric odour. (Shen Jizeng 1965; Xu Tiansen 1984a; Wang Shufen et al. 1990). Female adults have a strong preference in the selection of egg-laying site; eggs are mostly found on hot and dry sites with deep and loosened soil.

DAMAGE CAUSED

One of the most destructive of all pest insects on *P. pubescens*. New culms die and old ones fail to produce shoots in 2-3 years following even a single outbreak.

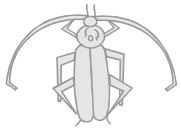
CONTROL

Soil-turning or spraying white fungus can play an important role in suppressing the population. If the locust population level is high, chemical control may be needed. The best methods are dusting BHC or spraying pyrethroids to control the newly hatched nymphs feeding in groups on small bamboo plants and wild grass, or smoking after they move on to bigger plants (Xiao Gangrou 1954; Ding Daomo and Zhang Shimei 1956; Anonymous 1960). Trapping is also recommended for controlling the locust (Guo Peide 1989). Xiao Gangrou (1959) has reviewed the biology and control measures of the locust.

Ceracris nigricornis Walker
Ceracris nigricornis laeta Bolivar

DISTRIBUTION

Commonly seen in bamboo-growing areas in central and southern China.



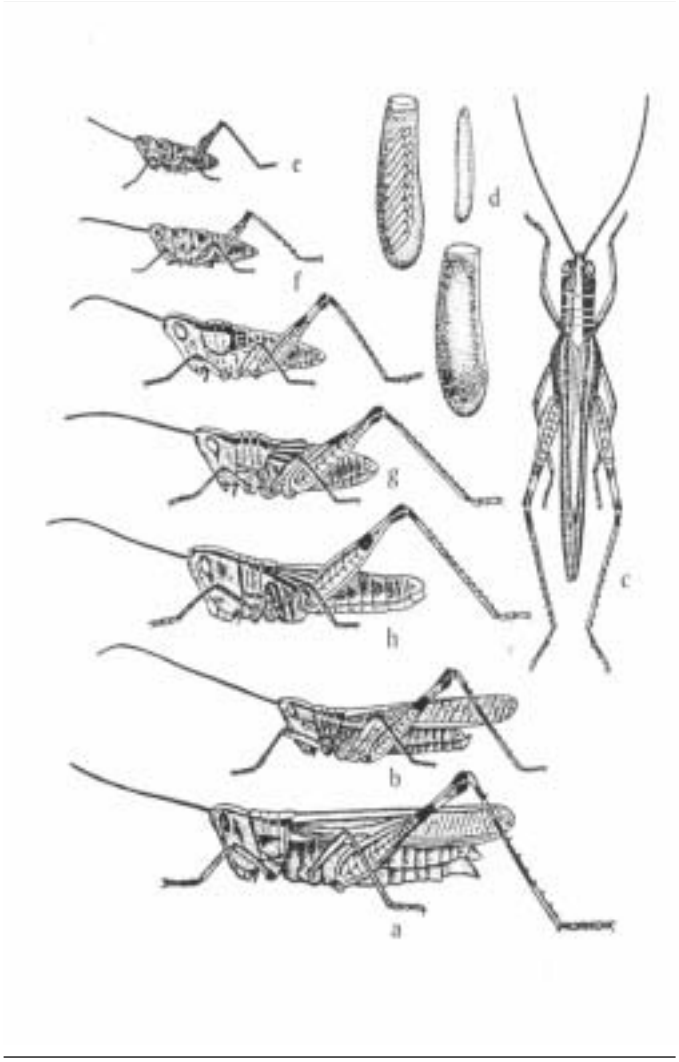


Fig. 1: Yellow-spined bamboo locust - ***Ceracris kiangsu*** a: female adult; b: male adult; c: back view of adult; d: egg and egg capsule; e-k: 1st to 5th instar of nymph

BIOLOGY

There is one generation per year for both species. Eggs are laid in winter in egg-capsules in the soil. Nymphs and adults emerge from April to early August and from July to mid December, respectively. They rarely reach epidemic population level, and often occur together with ***C. kiangsu*** (Shen Jizeng 1964).

Fig. 2: Adult of yellow-spined bamboo locust - ***Ceracris kiangsu***

Phlaeoba angustidorsis Bolivar

DISTRIBUTION

Widespread in central and south-eastern China.

HOSTS

Attacks mainly *Phyllostachys* species.

BIOLOGY

The adult is 20-30 mm long and has the colour of dry-grass. The front of the adult noticeably extends forwards and the protergum is ridged. The wings are shorter than the abdomen in length. There is one generation per year, and eggs overwinter in capsules laid in the soil from August to May. Nymphs hatch in May and take 45-50 days to develop fully, passing through four instars for males and five instars for females. Adults emerge from July to October and their longevity ranges from 90 to 110 days (Xu Tiansen and Lu Ruoqing 1987a).

Rice grasshopper - *Hieroglyphus banian* Fabricius

DISTRIBUTION

Parts of India; a serious epidemic of this species was recorded in Punjab during 1933-35 (Beeson 1941).

HOSTS

Principally a pest of rice, maize and wild grass; frequently affects *Dendrocalamus strictus.*

BIOLOGY

Green or brownish in colour. The adult lays eggs in the soil in November which do not hatch till June/ July, the following year (Beeson 1941; Browne 1968).

CONTROL

Control measures have been described by Main (1912), and Rao and Cherian (1940). Eggs are parasitized by *Scelio hieroglyphii* Timb. (Hymenoptera). Dusting hoppers and adults with 5% and 10% BHC dust, respectively, gives effective control (Singh and Bhandari 1988).

Hieroglyphus tonkinensis Bolivar

DISTRIBUTION

Southern China.

HOSTS

Reported as an important pest insect of various bamboos classified to the genera of *Bambusa, Sinobambusa, Lingnania, Dendrocalamus* and *Phyllostachys.* The insect also attacks sugar-cane, rice and some other agricultural crops when bamboo leaves are in short supply.

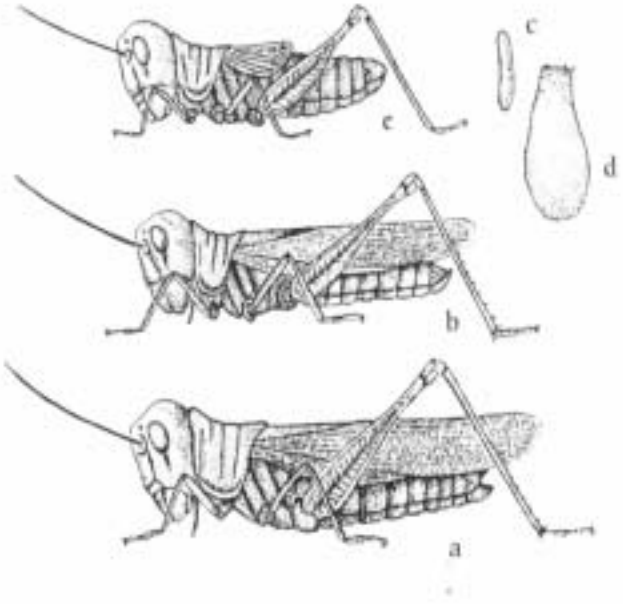


Fig. 3: ***Hieroglyphus tonkinensis***
a: female adult; b: male adult; c: egg;
d: egg-capsule; e: nymph

BIOLOGY

The adult is 35-52 mm long and light green in colour. There are five prominent sulci on the protergum of the adult. There is one generation per year, and eggs overwinter in capsule in the soil from August to April. Nymphs hatch in April and May, and there are six or seven instars. Nymphs are not very active and feed in groups on small bamboo plants and some grass at the first instar and then, move on to bigger plants. Adults emerge during June-August. (Huang Zenghe et al. 1982; Chen Wenjie et al. 1988, 1989).

CONTROL

Control measures recommended for ***C. kiangsu*** can be used.

Poecilocerus pictus Fabricius

DISTRIBUTION

Reported in India as occasionally causing severe defoliation in bamboo forests in dry regions, and as a serious pest in forest nurseries in Pakistan (Beeson 1941; Browne 1968).

HOSTS

Primarily an agricultural pest, but also injurious to *Dendrocalamus strictus.*

BIOLOGY

P. pictus has conspicuous, bright, bluish-green and yellow colours. The grasshopper has an annual life cycle and hibernates in the egg stage. Eggs are laid in masses in the soil.

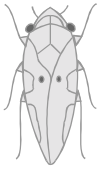
CONTROL

Dusting hoppers and adults with 5% and 10% BHC, respectively, is an effective control measure (Pruthi 1939).

Desert locust - *Schistocera gregaria* Forskal

DISTRIBUTION

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.



HOSTS

In the gregarious phase, all bamboo species besides other vegetation; in the solitary phase, *Dendrocalamus strictus*.

CONTROL

Various vertebrates and invertebrates prey upon adults and nymphs (Rao 1960). Birds — especially kites, crows and starlings — are predators of the locust. Larvae of *Troxprocerus* sp. (Coleoptera) has been found to cause 100% destruction of locust eggs sometimes (Bhatia and Singh 1962).

Leaf Rollers (Lepidoptera: Pyralidae)

Leaf rollers are one of the most important groups of leaf feeders on bamboo. About 15 species of bamboo leaf rollers have been reported as attacking various bamboos in Asia. Several species often occur together. The damage is caused by larvae, which tie leaves together as leaf cases and feed on the upper tissues of the leaves. Outer leaves of the rolled leaf cases often wither and eventually fall off. The damage is conspicuous at the top of culms and branches. Outbreaks are often reported in China, India, Japan and Korea causing serious defoliation, resulting in reduced vigour and even the death of culms. Damage is found to be more severe in plantations than in natural stands and individual plantings.

Greater bamboo leaf roller - *Algedonia [Pyrausta] coclesalis* Walker

DISTRIBUTION

The most common and destructive among the bamboo leaf rollers found in Bangladesh, Cambodia, China, India, Indonesia, Japan, Korea, Laos, Myanmar, Pakistan, Sri Lanka and Vietnam.

Fig. 4: Leaf cases made by bamboo leaf rollers

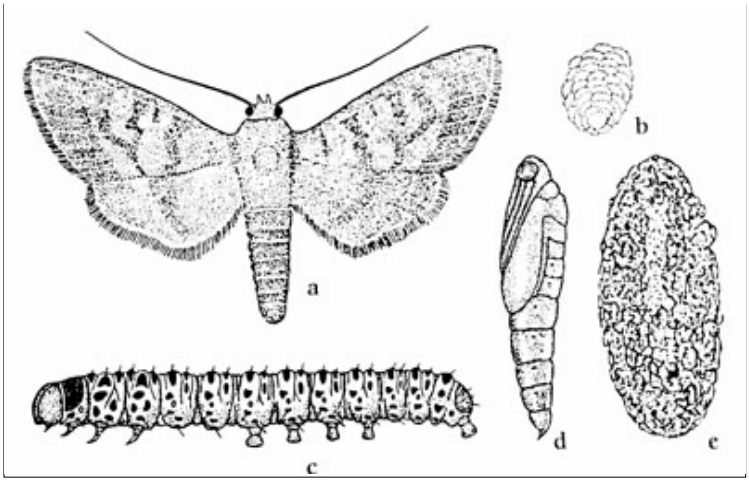


Fig. 5: The great bamboo leaf roller - ***Algedonia [Pyrausta] coclesalis*** a: adult; b: egg; c: larva; d: pupa; e: cocoon

HOSTS

Attacks many bamboo species, particularly *Phyllostachys pubescens, P. viridis, Bambusa vulgaris, Dendrocalamus latiflorus, D. strictus, D. giganteus, Schizostachyum pergracile* and *Arundinaria* spp.

BIOLOGY

The adult moth is 9-13 mm long and yellowish-brown in colour, with silvery white underside. There are up to four generations per year, depending on the bamboo species it attacks. Larvae occur during May-July, July-September, August-October and September-November for the four generations in southern China. In India, the pest occurs in three generations per year from June to September (Mathur 1943). Adults are active at night, with strong phototaxis. Before mating and egg-laying, they need to feed on flower juice of some trees, preferring *Castanea henryi* and *Quercus* spp. Eggs are deposited in groups on the back surface of leaves or on culms.

The initial larvae need to feed on newly-sprouted leaves. This special need gives rise to different population development models in different bamboo species. In stands of *Arundinaria, Bambusa* and *Dendrocalamus,* which produce new leaves almost throughout the year and new shoots evenly between years, there is no limitation in food supply; hence, the insect population level remains stable throughout the year. In *Phyllostachys pubescens* stands, however, new leaves are available mainly in spring, and the population of the pest decreases sharply from the second generation onwards because of high mortality of young larvae owing to insufficient food supply. Moreover, the alternation of so-called 'on year' and 'off year' of shoot producing in *P. pubescens* stands

makes the moths migrate from 'off year' stands to 'on year' stands for building up the first generation.

There are 7-8 larvae instars. The light green larvae feed in groups for the first two instars and individually after the third instar. After consuming about half of the leaf tissues, they give up the old leaf cases and make new ones. From the sixth instar onwards, they change cases almost every day. Feeding begins in the upper crown and move downwards. Larval stage varies from 18 to 36 days. When fully grown, the larvae drop to the ground, burrow into the surface soil and pupate in separate cocoons. In India, they are reported to pupate in cocoons made between the rolled leaves (Mathur 1943).

DAMAGE CAUSED

The attacked bamboos show skeletonized and brownish leaves webbed together in bunches. The outer leaves of the roll gradually wither, turn pale or straw coloured and eventually drop off.

CONTROL

Natural enemies of the leaf roller include various birds, spiders, ants, mantis, bugs and many parasites. Fully developed larvae are also infected by the white fungus at the rate of 14.1- 44% (Xu Tiansen and Zhao Jingnian 1974, 1976b; Xu Tiansen and Sun Yongchun 1978). However, these natural enemies are often unable to control the pest fully, resulting in epidemics.

Soil-turning in winter to kill overwintering insects can be employed against the leaf roller (Cao Zhifang and Xia LJ 1987). Local application of 0.2% fenitrothion or 0.1% carbaryl in water gives effective control. The insecticides may also be aerially sprayed, or injected in the culm cavity (Shi Quantai 1980).

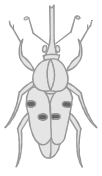


Fig. 6: Adult of ***Algedonia [Pyrausta] coclesalis***

Lesser bamboo leaf roller - *Algedonia [Pyrausta] bambucivora* Moore

DISTRIBUTION

The lesser bamboo roller is found in Bangladesh, India (north-west Himalayan region and Punjab) and Pakistan.

HOSTS

Bambusa nutans, B. vulgaris, Dendrocalamus giganteus, D. strictus and *Schizostachyum pergracile.*

BIOLOGY

The smooth pinkish larvae feed inside the rolled leaves of the host and eventually pupate in cocoons. The species has four generations per year.

CONTROL

Applying of 0.2% fenitrothion or 0.1% carbaryl in water with a sticker gives effective control.

Eumorphobotys obscuralis Caradja

DISTRIBUTION

China and Japan.

Fig: 7: Adult of ***Eumorphobotys obscuralis***

HOSTS

Reported to attack some *Phyllostachys, Bambusa* and *Dendrocalamus* species (Xu Tiansen 1985a).

BIOLOGY

The adult moth is 12-16 mm long and reddish-brown in colour. There are two generations per year overwintering as young larvae in leaf case, or three generations overwintering as fully fed larvae in cocoons. Adults are active at night, with strong phototaxis, and feed on flower juice of wild grass before mating. Eggs are laid in clusters on leaves and take 6-10 days to hatch. Larvae feed individually in leaf cases during June-July, August-September and October-May (for three generations). There are 6-7 larvae instars. Fully grown larvae pupate in thin, silken cocoons made beneath fallen sheaths on the ground, or in culm cracks or holes.

E. eumorphalis occurs in less incidence and causes damage similar to ***E. obscuralis***.

Circobotys aurealis Leech
Crocidophora evenoralis Walker

DISTRIBUTION

China, Japan, Korea and Myanmar.

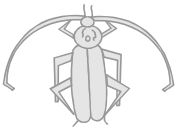


Fig. 8: Adult of ***Circobotys aurealis***

Fig. 9: Adult of ***Crocidophora evenoralis***

HOSTS

Both are commonly seen on *Phyllostachys, Bambusa* and *Pleioblastus* species.

BIOLOGY

For both the species, there is one generation per year. The adult moths, active at night and displaying strong phototaxis, need to feed before mating. Adults of ***C. aurealis*** emerge in April and May. Eggs are laid in groups mostly on leaves, but also on culms, and take 5-8 days to develop. Larvae feed individually inside leaf cases from May to August. There are six larval instars. The fully grown larvae pupate in thin, silk cocoons made under ground leaf letter.

Adults of ***C. evenoralis*** emerge in May and feed on tree flower juice for about one week before mating.

Eggs, which are laid in clusters on the back surface of leaves in the upper crown, take about a week to hatch. Larvae remain in leaf cases for 11 months, feeding in groups at the first two instars and individually thereafter. The third instar larvae diapause in leaf cases during summer and winter months and become active in early March (Xu Tiansen 1989, 1992a; Nakahara and Kobayashi 1963).

Crocidophora ptyophora Hampson

DISTRIBUTION

India and Myanmar.

BIOLOGY

The adult moth of this minor pest has bright yellow wings with broad purplish marginal bands. The larva rolls up green leaves with silken thread and feeds on the inner leaves. When about to pupate, it constructs a thick cocoon. The pupation period is 9-13 days.

Demobotys pervulgaris Hampson

Fig. 10: Adult of ***Demobotys pervulgaris***

DISTRIBUTION

China.

HOSTS

Attacks *Phyllostachys pubescens* in central China (Xu Tiansen 1992a).

BIOLOGY

The pyralid occurs one generation per year and overwinters as fully grown larvae. Adults emerge in May. They are active at night, with strong phototaxis, and need to feed for about a week before mating. Eggs are laid on the back of leaves in the upper crown and larvae hatch out in 8-11 days. There are 5-7 larval instars lasting 30-44 days. Very young larvae feed in groups, and fully developed larvae pupate in leaf litter on the ground.

CONTROL

This bamboo leaf roller usually keeps a low population level, mainly because of the parasitic *Acropimpla indicate* Fab. and *Chelonus* sp. as well as the white fungus which together cause about 65% death among the overwintering larvae. Soil-turning in winter to kill overwintering insects can be employed as a control measure (Cao Zhifang and Xia LJ 1987).

Cotton leaf roller - *Sylepta derogata* Fabricius

DISTRIBUTION

Bangladesh, India and Pakistan.

HOSTS

The pest is polyphagous, and attacks agricultural crops and forest plants apart from several bamboo species.

BIOLOGY

The moth is pale yellow in colour. The eggs are laid

Fig. 11: Adult of ***Sylepta derogata***

in rolled leaf cases. The larvae, on hatching, feed gregariously on the rolled leaf and subsequently migrate to form its own roll, where they feed. Pupation is in the soil or litter. The life cycle varies from 23 to 45 days, at times prolonged by larval aestivation and hibernation (Beeson 1941; Browne 1968).

Pionea flavofimbriata Moore

DISTRIBUTION

India and Sri Lanka.

HOST

Dendrocalamus strictus.

BIOLOGY

Adult moths are brown in colour with brownish-grey wings and actively fly about at dusk and night. The larvae gnaw through the upper tissue of the leaf causing a skeletonized effect on the leaf or eat the leaves from the edges in a ragged manner. The larvae

construct a silken cocoon on leaf surface and hibernate from November till the emergence of the moth in the following March (Mathur 1943).

CONTROL

The pest is a minor one, although sporadic epidemics do occur. It is parasitized by *Microgaster kuchingesnis* Walkn. Foliar spray of 0.1-0.2% fenitrothion or 0.1% carbaryl in water controls the pest.

Massepha absolutalis Walker

DISTRIBUTION

Bangladesh, India and Sri Lanka.

HOST

A regular defoliator of *Dendrocalamus strictus,* but not considered a pest of significance (Browne 1968).

BIOLOGY

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 (Beeson 1941).

CONTROL

The larvae is parasitized by some species of *Chelomus, Brachymeria* and *Tetrastichus* (Mathur 1943).

Microstaga jessica

DISTRIBUTION

Japan and Korea.

HOSTS

Phyllostachys edulis and *P. nigra.*

BIOLOGY

It has one generation per year and overwinters as matured larvae. An outbreak of the pest, together with several other leaf rollers, was observed in Kyoto, Japan in 1957 (Nakahara and Kobayashi 1963; Kim and Lee 1986).

A NOTE ON CONTROL OF LEAF ROLLERS

Control measures for suppressing pest population have proven effective against leaf rollers. Light-trapping of moths at nights during adult stage, and spraying insecticides on plants — such as *Castanea henryi* and *Ouercus* spp. — on which adult moths feed in groups are very effective in reducing the leaf-rollers' population in the following generation (Huang Ertian 1984). Artificial releasing of *Trichogramma* spp. in bamboo stands is practised and found effective (Xu Tiansen and Zhao Jingnian 1976a; Jin Changle et al. 1980; Liu Ruilan 1988). Chemical control may be necessary when heavy attacks occur. Satisfactory results can be obtained in bamboos with large culms by injecting systemic insecticides in the culm cavity (Anonymous 1979; Lan Linfu 1980).

Puss Moths (Lepidoptera: Notodontidae)

Eleven species of bamboo puss moths have been documented as bamboo pests (Cai Rongquan 1986). They are mostly large or middle-sized species. Their larvae can consume large amounts of foliage, often causing heavy defoliation.

Besaia goddrica Schaus

DISTRIBUTION

China.

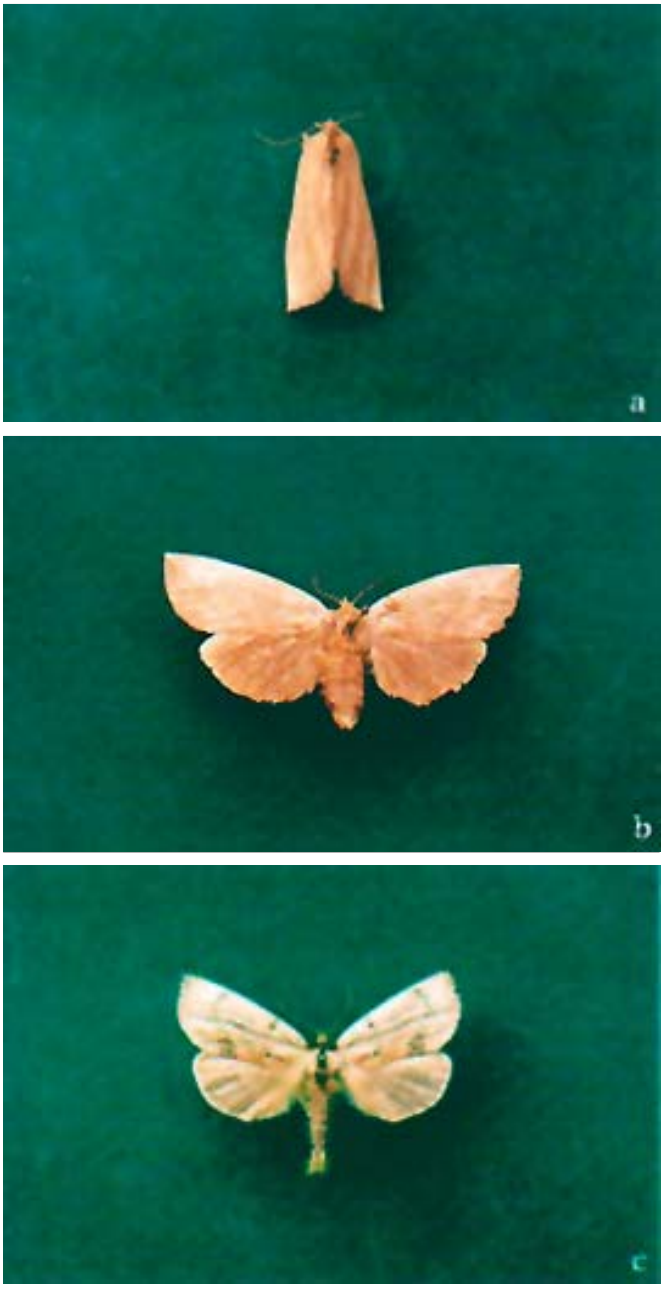


Fig. 12: Adults of ***Besaia goddrica*** a, b: female; c: male

HOST

One of the most common puss moth species on *Phyllostachys* species.

Fig. 13: Defoliation on *P. pubescens* caused by ***Besaia goddrica***

BIOLOGY

There are four generations per year. Larvae overwinter on leaves, but keep feeding when the weather is warm at day time. Moths, which are 20-25 mm long and light brown in colour, emerge in April-June, June-July, August-September and September-November, and are active at night showing strong phototaxis. The milk-white eggs are laid in a single row of 8-10 eggs on leaves. The egg stage lasts 6-10 days. The newly emerged larvae feed on the shell of eggs and are inert for 4-12 hours before starting to feed on leaves. There are 5-7 larvae instars, varying with generations. The fully grown larvae drop to the ground and pupate in earth cocoons at 2-3 cm depth.

CONTROL

Ants, spiders, mantis, birds and *Sirthenea flavipes* Stal. are found to be predators of the larvae. Parasitizing

Fig. 14: ***Besaia goddrica*** a: Larva; b: pupa and cocoon

enemies mainly include *Trichogramma* sp., *Telenomus* sp., *Exorista civilis* Rondani and *Tetrastichus* sp. (Xu Tiansen and Lu Ruoqing 1990).

Loudonta dispar Kiriakoff

DISTRIBUTION

Central and southern China.

HOST

Phyllostachys spp. and *Pleioblastus* spp.

BIOLOGY

The adult moth of this important pest is 13-23 mm long and light yellow or yellowish-brown in colour. The larvae are dark red but change to yellowish-brown from the second instar and subsequently to dark green when fully fed. There are three generations per year, overwintering as larvae on leaves. Adults are active at night and display phototaxis. Egg masses containing several rows of eggs are laid on young leaves in the upper crown. The eggs are light red in colour and turn to reddish-purple before hatching (but the parasitized ones turn dark brown or black). The egg stage lasts 4-12 days, varying with generations. There are 5-7 larval

Fig. 15: Adult of ***Loudonta dispar*** a: female; b: male

instars. The larvae feed on the shell of hatched eggs at the first instar and on leaves from the second. Fully fed larvae pupate in simple cocoons made from fallen leaves and soil particles in ground leaf litter.

CONTROL

Trichogramma spp. and *Telenomus* spp. are important egg parasites of the pest and can cause high mortality (up to 80%) of eggs of the third generation. Other parasites of the pest include *Rhogas* sp. and *Campoplex* sp. on larvae, and *Tetrastichus* sp. on pupae. (Anonymous 1976; Xu Tiansen and Lu Ruoquing 1987b).

Other Puss Moths

There are several other puss moth species commonly seen on bamboos: ***Stenadonta radialis*** Gaede in China and India (on *Phyllostachys* spp. and *Dendrocalamus latiflorus*); ***Mimopydna insignis*** Leech and ***Liccana terminicana*** Kiriakoff in China; ***Norraca retrofusca*** De Joannis and ***N. decurrens*** Moore in China, India and Vietnam; ***Oraura ordgara*** Schau. in China and the Philippines; and ***Niganda strigifascia*** Moore in Bhutan, China, India, Indonesia and Sikkim (on *Phyllostachys* spp. and *Arundinaria* spp.).

Fig. 16: Adult of ***Stenadonta radialis***

Fig. 17: Adult of ***Mimopydna insignis***

These species have similar life histories and damaging habits. There are 3-4 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 of 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. Chemical control against outbreaks can be achieved by smoking or spraying dichlorvos, or by cavity-injection of systemic insecticides in the case of bamboo species with large-sized culms.

Tussock Moths (Lepidoptera: Lymantriidae)

Some 16 tussock moth species have been recorded feeding on bamboo and are classified to various genera, of which ***Pantana*** is the most important.