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Forest pests in Central America

FIELD GUIDE

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TROPICAL AGRICULTURE
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This guide was prepared by consultants sponsored by CATIE's Multipurpose Tree Crop Project, MADELEÑA, and the content does not necessarily reflect the views of CATIE. The consultants were wholly responsible for field collection, information processing and the preparation of this guide in keeping with the terms of reference of the consultancy.

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PRESENTATION

There has been growing interest in tree production in Central America in recent years resulting from support to silvicultural research. This interest can be observed throughout communities where small plantations of mixed species have started to appear.

The LEÑA and MADELEÑA Projects, developed by CATIE in Central American countries from 1980 to 1991 and funded by ROCAP, have stimulated this interest and increased the number of species now being used.

In order to develop silviculture as a productive activity capable of competing with traditional production, many aspects needed consideration. A plant health study of the 14 priority species was considered fundamental to complement the efforts made in silviculture. The study covered the recognition of pests and diseases found in different stages of tree development from seed and nursery to mature forest.

This line of research is also fundamental for ensuring success in establishing forestry plantations. It is well known that as the population of one forest species increases, so the risk of prejudicial pests or diseases also increases.

The regional level plant health evaluation was complemented by the preparation of a "Field Guide and a Handbook for forest pests and diseases".

It is hoped that these two documents will be useful tools, both for those carrying out research in pests and diseases of tropical forest species and for educators and extensionists who must cater to the producers' needs.

Rodolfo Salazar
MADELEÑA Project Leader

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The consultants

PREFACE

Many organisms go unnoticed by man, unless they impinge on his activities or interests. In Central America, plant health problems have grown to an unprecedented level during the last few years along with the establishment of extensive, homogeneous forest plantations.

In some cases, a panic reaction has resulted in the application of drastic solutions such as widespread felling and the massive application of pesticides. Rarely has the organism's damage potential, risk of spreading or host range been thoroughly analyzed in order to come up with less radical or expensive measures. The situation could be summarized in two words: ignorance and desperation.

There are no simple measures for overcoming ignorance and coping with desperation but efforts must be made immediately to find remedies. Starting with an appropriate theoretical strategy, there must be observation, analysis, trials of new techniques and organization of findings to resolve field problems. To a great extent, this is what members of PIPROF (Programa Interinstitucional de Protección Forestal) have achieved in Costa Rica since 1984. They have been aware that there is little available information for combating plant health problems in nurseries, plantations and forests.

When the MADELEÑA Project first approached us regarding the consultancy, which included the preparation of a field guide and a handbook, we were apprehensive in view of the complexity and scope of the work. However, we soon realized the need to fill the large gap that exists in information in the region. When we later visited the countries of the area, we were even more sure that there was an urgent need for published material in the field of forest protection.

It is with great satisfaction that we present the Field Guide and the Handbook which, in reality, together constitute a single work. The Field Guide concentrates on 18 trees considered priority species by MADELEÑA, and is designed for field use. It gives fast identification of damage agents and offers some general information on their biology and epidemiology. The Handbook contains theoretical information at greater depth, such as guidelines for plantation inspection and pest management in general, making it, in practice, inseparable from the Guide. The authors feel that the information given in the Handbook will help provide better criteria for confronting any novel plant health problems not covered by the Guide.

It should be noted that there is a marked bias, especially in the Guide, to plant health problems found in Costa Rica. This is due, in part, to Costa Rica being the seat of PIPROF, the organization which has been gathering information continually for six years. Only one week was

allowed for collecting samples from other countries in the region and, for operational reasons, identifiable forms of the material being reared or grown in the national laboratories was not always available.

Lack of expertise and the operational difficulties mentioned above have meant that the works may lack polish and depth. Both the Guide and the Handbook should be regarded as preliminary texts which will, in later editions, include material omitted involuntarily as well as new knowledge acquired in the future. With this in mind, the authors would be grateful to receive any information or suggestions to improve and amplify the works. Amongst the more ambitious hopes is the establishment of a regional forestry protection network to facilitate the exchange of information and observations. It is hoped that these documents will act as catalysts for this important endeavor.

We hope that the continued use of these two complementary texts will help overcome the ignorance of pests affecting nurseries, plantations and forests and help dispel the desperation which has so often led to ill advised solutions.

The consultants

GENERAL NOTES FOR USE OF THE GUIDE

1. The Guide is made up of two large general sections: the lists of pests of the MADELEÑA Project forest species and the more detailed monographs, which will be referred to simply as the "lists" and "monographs".

2. There are two lists organized as follows: according to the host affected and according to the structure damaged. In this way the user can use either route to identify the pest.

3. The order of the first list is as follows: insects, vertebrates, pathogens and plant parasites. The list is made up of four columns: scientific name of damage agent, type of damage, stage at which the plant is affected and severity of the problem.

4. In the first column, where the pests are insects or vertebrates, the name of the order (abbreviated) and family (in full) to which they belong appears underneath. The abbreviations used are as follows: for insects, COL. (Coleoptera), DIPT. (Diptera), HEM. (Hemiptera), HOM. (Homoptera), HYM. (Hymenoptera), ISO. (Isoptera), LEP. (Lepidoptera), SALT. (Saltatoria) and THYS. (Thysanoptera) for vertebrates, ART. (Artiodactyla), EDE. (Edentata), LAG. (Lagomorpha), PRI. (Primates), ROD. (Rodentia) and SAU. (Sauria).

5. Pathogens are referred to only by genus or species name and sometimes only common name. Where the common name refers to an abiotic disease, it appears in parentheses.

6. Not all observed species were be fully identified. In some cases they are only identified to genus, family or even order level. The publication by FORD (1981), was essential for this section of the Guide. Genus and species names appear in alphabetical order followed by the common names of those species not identified, also in alphabetical order.

7. The second column only mentions the type of damage. The appearance and results of the damage can be found in Chapter II of the Handbook.

8. In the third column, four stages of growth or types of plant are identified: S (seeds), N (seedlings or stumps in nurseries), Y (young trees less than three years old) and M (trees over three years old).

9. The fourth column refers to the severity of the problem: C (chronic problem, nearly always present, sometimes reaching epidemic proportions), S (sporadic problem, requiring control measures on at least one occasion) and R (registered problem, observed on at least one occasion).

10. The second list contains only two columns , one with the scientific name of the damage causing agent and the other with the scientific name of the affected tree. In certain cases such as pines and eucalypts, the plural form is used without distinguishing species.

11. Throughout the text, scientific names are used in preference to common names, since these can result in confusion. The end of the guide includes an appendix of common names in both English and Spanish for thirty nine of the plants most commonly referred to in the text.

12. In the case of insects which attack seedlings, only those completely consuming the plants are included. Obviously other insects which attack just leaves, buds or shoots can also cause serious problems in nurseries.

13. Chapter IV of the Handbook should be consulted for evaluating the possibilities of chemical control. This chapter contains the relevant recommendations according to the parts damaged by each species.

14. Both the lists and the monographs use abbreviations derived from Latin or Greek which may require explanation. The abbreviation "sp." after a generic name implies that the organism is only identified to genus and not species level (e.g. ***Aepytus*** sp.). Where several species of the same genus are identified to genus level only, the plural form "spp." is used (e.g. ***Atta*** spp.). Other abbreviations used are: "ca." meaning "close to", "cf." meaning "possibly" and "syn." meaning "synonymous" where a genus or species has previously had a different name e.g. ***Cryphonectria*** (syn. ***Diaporthe***) ***cubensis***. The abbreviation "pv." signifies pathovar or pathogenic variant of some bacteria.

15. The monographs include biological or epidemiological information and the type of damage produced by families and species of pests. They also contain details of alternative hosts and information on families and species which, as yet, are not a problem in Central America, but might be in the future.

16. With the exception of the vertebrates, the monographs are arranged alphabetically by order and also within each order.

17. A bibliography is included at the end of each monograph. Some information is from the unedited work of the authors. The excellent works of BORROR *et al.* (1976) and STEHR (1987), along with GRAY (1972, 1978) and HOCHMUT and MANSO (1982) were used as a basis for the insect family monographs, but are not cited each time to avoid repetition. The work by FERREIRA (1989) was invaluable for the pathogen monographs.

18. All drawings accompanying the monographs were made to the same size and all photographs taken with the maximum magnification available. For this reason, few correspond to the life size of the organism illustrated.

19. The final pages of the Handbook contain a glossary of scientific terms used but not explained in the text.

CONTENTS

LISTS OF PESTS

CHAPTER I

1. ACCORDING TO HOST TREE

Acacia mangium (Acacia)
(MIMOSACEAE)

INSECTS

Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C*
Brachypnoea sp. (COL., Chrysomelidae)	Defoliation	Y,M	R
Phyllophaga sp. (COL., Scarabaeidae) (White grub)	Root destruction	N,Y	C
Platypus sp. (COL., Platypodidae)	Xylem boring	M	S
Trigona fuscipennis (HYM., Apidae) (Stingless bee)	Defoliation	Y,M	S
Trigona silvestriana (HYM., Apidae) (Stingless bee)	Bark chewing	M	S
Bark beetle (COL., Scolytidae)	Xylem boring	M	S

VERTEBRATES

Dasyprocta punctata (ROD., Dasyproctidae) (Agouti)	Bark chewing	M	R
Dasypus novemcinctus (EDE., Dasypodidae) (Armadillo)	Seedling removal	N,Y	R
Sigmodon hispidus (ROD., Cricetidae) (Hispid cotton rat)	Bark chewing	M	R

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*/ See pages **xi, xii**; notes 4, 8 and 9 for explanation of letter code.

PATHOGENS

Botryodiplodia sp.	Foliage	M	R
Cladosporium sp.	Foliage	M	R
Erwinia sp.	Branches	M	R
Fusarium sp.	Branches	M	R
Pestalotia sp.	Foliage	M	R
Puccinia sp.	Foliage	M	R
Rhizoctonia solani	Roots	N	S

PARASITIC PLANTS

Struthanthus leptostachyus (Mistletoe)	Foliage	M	R

Alnus acuminata (Alder)
(BETULACEAE)

INSECTS

Brachynoea sp. (COL., Chrysomelidae)	Defoliation	N,Y,M	S
Hypselonotus atratus (HEM., Coreidae)	Piercing - sucking	N,Y,M	S
Nodonota irazuensis (COL., Chrysomelidae)	Defoliation	N,Y,M	C
Scolytodes alni (COL., Scolytidae)	Bark destruction	M	S
Skeletonizing larva (LEP., Arctiidae)	Defoliation	Y,M	C

VERTEBRATES

Sciurus sp. (ROD., Sciuridae) (Squirrel)	Bark stripping	M	R
Sylvilagus brasiliensis (LAG., Leporidae) (Rabbit)	Seedling destruction	N,Y	S

PATHOGENS

Colletotrichum sp.	Foliage	M	R
Fusarium sp.	Seeds	S	S
Phomopsis sp.	Foliage	M	R
Rosellinia sp.	Stem, root	M	S
Trichoderma sp.	Seeds	S	R

Bombacopsis quinatum (Saquisaqui)
(BOMBACACEAE)

INSECTS

Acheta assimilis (SALT., Gryllidae) (Cricket)	Seedling destruction	N	S
Achyloides bursirus (LEP., Hesperiidae)	Defoliation	Y	R
Aepytus sp. (LEP., Hepialidae)	Pith boring	M	S
Agrotis sp. (LEP., Noctuidae) (Cutworm)	Seedling destruction	N	C
Arsenura armida (LEP., Saturniidae)	Defoliation	M	C
Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Caio championi (LEP., Saturniidae)	Defoliation	M	R
Elasmopalpus lignosellus (LEP., Pyralidae)	Seedling destruction	N	S
Eulepidotis sp. (LEP., Noctuidae)	Defoliation	Y,M	S
Lirimiris lignitecta (LEP., Notodontidae)	Defoliation	Y	R
Mozena sp. (HEM., Coreidae)	Piercing - sucking	Y,M	R
Pantomorus strabo (COL., Curculionidae)	Defoliation	N,Y,M	S
Paracarsidara sp. (HOM., Psyllidae)	Piercing - sucking	N,Y	S

Periphoba arcaei (LEP., Saturniidae)	Defoliation	M	R
Phyllophaga sp. (COL., Scarabaeidae) (White grub)	Root destruction	N,Y	C
Schistocerca piceifrons (SALT., Acrididae) (Locust)	Defoliation	Y,M	S
Steirastoma histrionicum (COL., Cerambycidae)	Boring of xylem and pith; bark chewing	Y,M	C
Chrysomelid beetle (COL., Chrysomelidae)	Defoliation	Y,M	R

VERTEBRATES

Alouatta palliata (PRI., Cebidae) (Howler monkey)	Seedling destruction, foliage consumption	N,M	R
Ctenosaura similis (SAU., Iguanidae) (Ctenosaur)	Seedling destruction	N	R
Odocoileus virginianus (ART., Cervidae) (White-tailed deer)	Seedling destruction	N,Y	S
Orthogeomys cherriei (ROD., Geomyidae) (Giant pocket gopher)	Seedling and tree destruction	N,Y,M	C
Sciurus variegatoides (ROD., Sciuridae) (Squirrel)	Bark chewing	M	S
Sigmodon hispidus (ROD., Cricetidae) (Hispid cotton rat)	Bark chewing	N,Y	C
Tayassu tajacu (ART., Tayassuidae) (Collared peccary)	Seedling destruction	N,Y	S

PATHOGENS

Colletotrichum dematium	Stem	N	S
Cylindrocladium sp.	Root	N	R
	Stem	N	R
Fusarium solani	Root	N	S
	Stem	N	S
Phomopsis salmonica	Stem	N	S
Rosellinia sp.	Root	M	R
	Stem	M	R
Scytalidium sp.	Stem	N	R
Verticillium sp.	Stem	N	R

Caesalpinia velutina
(CAESALPINIACEAE)

INSECTS

Skeletonizing larva (LEP., Tortricidae)	Defoliation	N,Y,M	S
Seed borer (LEP., not identified)	Seed destruction	S	S

PARASITIC PLANTS

Oryctanthus alveolatus (Mistletoe)	Foliage	M	R

Calliandra calothyrsus (Powderpuff)
(MIMOSACEAE)

INSECTS

Umbonia crassicornis (HOM., Membracidae)	Piercing - sucking	Y,M	R
Spittle bug (HOM., Cercopidae)	Piercing - sucking	Y,M	R

PARASITIC PLANTS

Struthanthus quercicola (Mistletoe)	Foliage	M	R

Casuarina equisetifolia (Casuarina)
(ROSACEAE)

INSECTS

Trigona silvestriana (HYM., Apidae) (Stingless bee)	Resin extraction	Y,M	R
Bark beetle (COL., Platypodidae)	Xylem boring	M	S

PATHOGENS

Fusarium sp.	Root	M	R
Pestalotia sp.	Foliage	M	R
Phomopsis sp.	Foliage Branches	Y,M Y	R R
Rhizoctonia solani	Root	N	R

PARASITIC PLANTS

Struthanthus orbicularis (Mistletoe)	Foliage	M	R

Cordia alliodora (Cypre)
(BORAGINACEAE)

INSECTS

Agrotis sp. (LEP., Noctuidae)	Seedling destruction	N	C
Amblycerus sp. (COL., Bruchidae)	Seed destruction	S	S
Automeris rubrescens (LEP., Saturniidae)	Defoliation	M	R
Captocycla dorsoplagiata (COL., Chrysomelidae)	Defoliation	N,Y,M	R
Captocycla leprosa (COL., Chrysomelidae)	Defoliation	N,Y,M	R
Charidotis vidreata (COL., Chrysomelidae)	Defoliation	N,Y,M	R
Clinodiplosis sp. (DIPT., Cecidomyiidae)	Gall formation	N,Y	S
Cropia phila (LEP., Noctuidae)	Defoliation	N,Y,M	R
Dictyla monotropidia (HEM., Tingidae)	Piercing - sucking	Y,M	C
Exophthalmus jekelianus (COL., Curculionidae)	Defoliation	N,Y,M	S
Macunolla ventralis (HOM., Cicadellidae)	Piercing - sucking	Y,M	R
Mocis latipes (LEP., Noctuidae) (Looper caterpillar)	Defoliation	Y,M	R
Nodonota irazuensis (COL., Chrysomelidae)	Defoliation	N,Y,M	S
Polydacrys sp. (COL., Curculionidae)	Defoliation	N,Y,M	R

Trigona silvestriana (HYM., Apidae) (Stingless bee)	Resin extraction	Y,M	R
White larva (COL., Cerambycidae)	Xylem boring	M	R
Mining larva (LEP., Lyonetiidae)	Leaf miner	N,Y	R
VERTEBRATES			
Basiliscus basiliscus (SAU., Iguanidae) (Jesus Christ Lizard)	Stump plant removal	N,Y	R
Dasypus novemcinctus (EDE., Dasypodidae) (Armadillo)	Stump plant removal	N,Y	R
Sylvilagus brasiliensis (LAG., Leporidae) (Rabbit)	Bark removal from stump plant	N,Y	R
PATHOGENS			
Cladosporium sp.	Foliage and seeds	Y,M	R
Uredo sp.	Foliage	N,Y,M	R
Xanthomonas sp.	Branches	M	R

Cupressus lusitanica (Cypress)
(CUPRESSACEAE)

INSECTS

Acheta assimilis (SALT., Gryllidae) (Cricket)	Seedling destruction	N	S
Agrotis ipsilon (LEP., Noctuidae) (Cutworm)	Seedling destruction	N	C
Agrotis sp. (LEP., Noctuidae) (Cutworm)	Seedling destruction	N	C
Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Brachypnoea sp. (COL., Chrysomelidae)	Defoliation	Y,M	S
Coptotermes crassus (ISO., Rhinotermitidae) (Termite)	Pith and xylem boring	M	S
Exophthalmus jekelianus (COL., Curculionidae)	Defoliation	N,Y,M	S
Exophthalmus sp. (COL., Curculionidae)	Defoliation	N,Y,M	S
Hylesia sp. (LEP., Saturniidae)	Defoliation	Y,M	S
Hypselonotus atratus (HEM., Coreidae)	Piercing-sucking	Y,M	R
Phyllophaga spp. (COL., Scarabaeidae) (White grubs)	Root destruction	N,Y	C
Platypus ca. ***dolabatrus*** (COL., Platypodidae)	Xylem boring	M	S

Platypus sp. (COL., Platypodidae)	Xylem boring	M	S
Bagworm (LEP., Psychidae)	Defoliation	Y,M	R
Chrysomelid beetle (COL., Chrysomelidae)	Defoliation	Y,M	R
VERTEBRATES			
Dasypus novemcinctus (EDE., Dasypodidae) (Armadillo)	Seedling removal	N,Y	R
Orthogeomys heterodus (ROD., Geomyidae) (Giant pocket gopher)	Seedling destruction	N,Y	C
Sciurus granatensis (ROD., Sciuridae) (Squirrel)	Bark chewing	M	S
PATHOGENS			
Alternaria sp.	Foliage	M	R
Asperisporium sequoiae	Foliage	M	S
Colletotrichum sp.	Foliage	M	R
Fusarium sp.	Seed	S,N	R
Pestalotia sp.	Foliage	N,Y,M	C
Poria sp.	Stem	M	R
Seiridium cardinale	Foliage	M	S
Verticillium sp.	Seed	S	R

Eucalyptus camaldulensis (Red river gum)
(MYRTACEAE)

INSECTS

Atta sp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Trigona sp. (HYM., Apidae) (Stingless bee)	Resin extraction	Y,M	S

PATHOGENS

Aulographina eucalypti	Foliage	M	S
	Branches	M	S
Corticium sp.	Root	M	R
Cylindrocladium scoparium	Foliage	M	R
Diplodia sp.	Foliage	M	R
	Root	M	R
	Stem	M	R

Eucalyptus deglupta (Kamarere)
(MYRTACEAE)

INSECTS

Acanalonia sp. (HOM., Acanaloniidae)	Piercing - sucking	Y,M	R
Aconophora ferruginea (HOM., Membracidae)	Piercing - sucking	Y,M	R
Aphis sp. (HOM., Aphididae)	Piercing - sucking	N,Y,M	S
Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Bolbonota inaequalis (HOM., Membracidae)	Piercing - sucking	Y,M	R
Ceresa concinna (HOM., Membracidae)	Piercing - sucking	Y,M	R
Clastoptera sp. (HOM., Cercopidae)	Piercing - sucking	Y,M	R
Coptotermes crassus (ISO., Rhinotermitidae) (Termite)	Xylem and pith boring	M	S
Enchenopa lanceolata (HOM., Membracidae)	Piercing - sucking	Y,M	R
Exophthalmus jekelianus (COL., Curculionidae)	Defoliation	N,Y,M	S
Graphocephala coccinea (HOM., Cicadellidae)	Piercing - sucking	Y,M	R
Graphocephala rufinago (HOM., Cicadellidae)	Piercing - sucking	Y,M	R
Hansenia pulverulenta (HOM., Flatidae)	Piercing - sucking	Y,M	R
Macunolla ventralis (HOM., Cicadellidae)	Piercing - sucking	Y,M	R

Membracis albolimbata (HOM., Membracidae)	Piercing - sucking	Y,M	R
Micrutalis lugubrina (HOM., Membracidae)	Piercing - sucking	Y,M	R
Nodonota irazuensis (COL., Chrysomelidae)	Defoliation	N,Y,M	S
Onchometopia sp. (HOM., Cicadellidae)	Piercing - sucking	Y,M	R
Platypus ca. ***godmani*** (COL., Platypodidae)	Pith boring	M	R
Saissetia sp. (HOM., Coccidae)	Piercing - sucking	Y,M	R
Selenothrips rubrocinctus (THYS., Thripidae)	Rasping - sucking	Y	S
Sibovia occatoria (HOM., Cicadellidae)	Piercing - sucking	Y,M	R
Sphenorhina conspicua (HOM., Cercopidae)	Piercing - sucking	Y,M	R
Trigona corvina (HYM., Apidae) (Stingless bee)	Bud cutting	Y	S

VERTEBRATES

Orthogeomys heterodus (ROD., Geomyidae) (Giant pocket gopher)	Seedling destruction	N,Y	C

PATHOGENS

Agrobacterium tumefasciens	Stem	N	R
Botrytis sp.	Foliage	N	R
Colletotrichum sp.	Foliage	N,Y	R
Corticium salmonicolor	Branches	Y,M	S

Diplodia sp.	Foliage	Y	R
Pestalotia sp.	Foliage	N,Y	R
Phytophthora sp.	Root	M	R
Pseudoseptoria sp.	Foliage	N	R

Eucalyptus saligna (Saligna gum)
(MYRTACEAE)

INSECTS

Acheta assimilis (SALT., Gryllidae) (Cricket)	Seedling destruction	N	S
Agrotis ipsilon (LEP., Noctuidae) (Cutworm)	Seedling destruction	N	C
Atta sp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Trigona silvestriana (HYM., Apidae) (Stingless bee)	Resin extraction	M	S

VERTEBRATES

Orthogeomys heterodus (ROD., Geomyidae) (Giant pocket gopher)	Seedling destruction	N,Y	C
Sciurus variegatoides (ROD., Sciuridae) (Squirrel)	Bark stripping	N,Y	S

PATHOGENS

Cylindrocladium sp.	Foliage	M	R
Diplodia sp.	Root	M	R
Pestalotia sp.	Foliage	M	R

Gliricidia sepium (Mother of cocoa)
(LEGUMINOSAE)

INSECTS

Erynnis sp. (LEP., Sphingidae)	Defoliation	Y,M	R
Hylesia lineata (LEP., Saturniidae)	Defoliation	M	R
Spodoptera sp. (LEP., Noctuidae)	Defoliation	Y,M	R
Defoliating larva (LEP., Noctuidae)	Defoliation	Y,M	R
Defoliating larva (LEP., Pyralidae)	Defoliation	Y,M	R
Large headed larva (LEP., Hesperiidae)	Defoliation	Y,M	R
Hairy larva (LEP., Arctiidae)	Defoliation	Y,M	R
Hairy larva (LEP., Arctiidae)	Defoliation	Y,M	R
Aphid (HOM., Aphididae)	Piercing - sucking	N,Y,M	R
Spittle bug (HOM., Cercopidae)	Piercing - sucking	Y,M	S

VERTEBRATES

Orthogeomys cherriei (ROD., Geomyidae) (Pocket gopher)	Root destruction	Y,M	S

PATHOGENS

Colletotrichum sp.	Foliage	M	S
Cylindrocladium sp.	Foliage	M	S
Fusarium oxysporum	Root, stem branches	M	S
Pestalotia sp.	Foliage	M	R
Phoma sp.	Foliage	M	R

Gmelina arborea (Gmelina)
(VERBENACEAE)

INSECTS

Aepytus sp. (LEP., Hepialidae)	Pith boring	Y,M	C
Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Automeris rubrescens (LEP., Saturniidae)	Defoliation	Y,M	S
Lonomia electra (LEP., Saturniidae)	Defoliation	Y,M	S
Phyllophaga spp. (COL., Scarabaeidae) (White grubs)	Root destruction	N,Y	C
Schistocerca piceifrons (SALT., Acrididae) (Locust)	Defoliation	Y	S
Boring larva (LEP., Hepialidae)	Pith boring	Y	R

VERTEBRATES

Alouatta palliata (PRI., Cebidae) (Howler monkey)	Defoliation	Y,M	R
Aratinga canicularis (AVES, Psittacidae) (Orange-fronted parakeet)	Destruction of seeds, buds and leaves	Y,M	R
Basiliscus basiliscus (SAU., Iguanidae) (Jesus Christ lizard)	Stump plant removal	N,Y	R

Coendou mexicanum (ROD., Erethizontidae) (Prehensile-tailed porcupine)	Bark chewing	Y,M	R
Dasypus novemcinctus (EDE., Dasypodidae) (Armadillo)	Stump plant removal	N,Y	R
Sigmodon hispidus (ROD., Cricetidae) (Hispid cotton rat)	Bark chewing	Y,M	C
Sylvilagus brasiliensis (LAG., Leporidae) (Rabbit)	Bark chewing from stump plant	N,Y	R
PATHOGENS			
Colletotrichum sp.	Foliage	M	R
Phomopsis sp.	Branches Stem	Y	R
Pseudocercospora rangita	Foliage	N,Y	S
Rosellinia sp.	Root Stem	M M	R R

Guazuma ulmifolia (Guacima)
(STERCULIACEAE)

INSECTS

Aepytus sp. (LEP., Hepialidae)	Pith boring	Y,M	S
Arsenura armida (LEP., Saturniidae)	Defoliation	M	S
Automeris rubrescens (LEP., Saturniidae)	Defoliation	M	R
Epitragus sp. (COL., Tenebrionidae)	Defoliation	M	S
Hylesia lineata (LEP., Saturniidae)	Defoliation	M	R
Ledesmodina sp. (COL., Chrysomelidae)	Defoliation	Y,M	R
Leptostylus sp. (COL., Cerambycidae)	Trunk girdling	Y,M	S
Lirimiris truncata (LEP., Notodontidae)	Defoliation	M	R
Periphoba arcaei (LEP., Saturniidae)	Defoliation	M	R
Phelypera distigma (COL., Curculionidae)	Defoliation	Y,M	C
Cicada (HOM., Cicadidae)	Oviposition	Y,M	R

Leucaena leucocephala (Leucaena)
(MIMOSACEAE)

INSECTS

Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Centrinaspis lineelus (COL., Curculionidae)	Defoliation	Y,M	R
Hesperopanthia championi (HOM., Flatidae)	Piercing - sucking	Y,M	R
Heteropsylla cubana (HOM., Psyllidae)	Piercing - sucking	Y,M	S
Oncideres punctata (COL., Cerambycidae)	Trunk girdling	Y,M	S
Onchometopia sp. (HOM., Cicadellidae)	Piercing - sucking	Y,M	R
Cicada (HOM., Cicadidae)	Oviposition	Y,M	R
Defoliating larva (LEP., Tortricidae)	Defoliation	N,Y,M	R
Hairy larva (LEP., Arctiidae)	Defoliation	N,Y,M	R
Hairy larva (LEP., Arctiidae)	Defoliation	N,Y,M	R

PATHOGENS

Colletotrichum sp.	Stem	M	R
Fusarium sp.	Root	N	R
	Stem	N	R

Mimosa scabrella (Bracatinga)
(MIMOSACEAE)

INSECTS

Chrysobothris sp. (COL., Buprestidae)	Xylem boring	Y,M	S
Neoclytus sp (COL., Cerambycidae)	Xylem boring	Y,M	S
Red larva (LEP., Cossidae)	Xylem boring	Y,M	R
Bark beetle (COL., Scolytidae)	Xylem boring	Y,M	R

Pinus caribaea (Caribbean pitch pine)
(PINACEAE)

INSECTS

Acheta assimilis (SALT., Gryllidae) (Cricket)	Seedling destruction	N	S
Agrotis sp. (LEP., Noctuidae) (Cutworm)	Seedling destruction	N	C
Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Cinara sp. (HOM., Aphididae)	Piercing - sucking	N,Y	S
Conotrachelus sp. (COL., Curculionidae)	Cone destruction	S	S
Dendroctonus spp. (COL., Scolytidae)	Bark destruction	Y,M	C
Dioryctria erythropasa (LEP., Pyralidae)	Cone destruction	S	C
Dioryctria majorella (LEP., Pyralidae)	Cone destruction	S	C
Exophthalmus jekelianus (COL., Curculionidae)	Defoliation	Y	S
Hansenia pulverulenta (HOM., Flatidae)	Piercing - sucking	Y	R
Hylesia sp. (LEP., Saturniidae)	Defoliation	Y,M	S
Ips spp. (COL., Scolytidae)	Bark destruction	Y,M	C
Leptoglossus sp. (HEM., Coreidae)	Cone and seed destruction	S	S

Macunolla ventralis (HOM., Cicadellidae)	Piercing - sucking	Y,M	R
Megastigmus spp. (HYM., Torymidae)	Cone destruction	S	C
Neodiprion sp. (HYM., Diprionidae)	Defoliation	Y,M	S
Nodonota irazuensis (COL., Chrysomelidae)	Defoliation	Y	S
Phyllophaga sp. (COL., Scarabaeidae) (White grub)	Root destruction	N,Y	C
Rhyacionia frustrana (LEP., Tortricidae)	Shoot boring	N,Y,M	C
Rhyacionia subtropica (LEP., Tortricidae)	Shoot boring	N,Y,M	S
Sphenorhina conspicua (HOM., Cercopidae)	Piercing - sucking	Y,M	R
Tetyra sp. (HEM., Pentatomidae)	Cone destruction	S	S
Trigona corvina (HYM., Apidae) (Stingless bee)	Resin extraction	Y,M	S
Trigona cupira (HYM., Apidae) (Stingless bee)	Resin extraction	Y,M	S
Trigona ferricauda (HYM., Apidae) (Stingless bee)	Resin extraction	Y,M	S
Trigona silvestriana (HYM., Apidae) (Stingless bee)	Seedling destruction	N	S

VERTEBRATES

Dasypus novemcinctus (EDE., Dasypodidae) (Armadillo)	Seedling removal	N,Y	R

PATHOGENS

Diplodia sp.	Foliage	M	R
	Branches	M	R
Cercospora pinea	Foliage	M	R
Cronartium sp.	Branches	M	R
Dothistroma septospora	Foliage	M	S
Fusarium sp.	Root	N	R
Lophodermium sp.	Foliage	M	R
Phytophthora sp.	Root	M	R
Pleospora sp.	Foliage	M	R
Rhizoctonia solani	Root	N	S
Rosellinia sp.	Root	M	R

PARASITIC PLANTS

Arceuthobium vaginatum (Mistletoe)	Foliage	M	R

Tectona grandis (Teak)
(VERBENACEAE)

INSECTS

Atta spp. (HYM., Formicidae) (Leaf cutting ants)	Defoliation	N,Y,M	C
Neoclytus cacicus (COL., Cerambycidae)	Xylem borer	Y	R
Phyllophaga sp. (COL., Scarabaeidae) (White grub)	Root destruction	N,Y	C
Plagiohammus spinipennis (COL., Cerambycidae)	Xylem and pith boring	Y,M	C

VERTEBRATES

Orthogeomys underwoodi (ROD., Geomyidae) (Pocket gopher)	Seedling destruction	N,Y	R

PATHOGENS

Agrobacterium tumefasciens	Stem	Y,M	R
Corynespora sp.	Foliage	M	R
Fusarium oxysporum	Root Stem	N,Y	R

2. ACCORDING TO STRUCTURE ATTACKED

INSECTS

A. REPRODUCTIVE PARTS

a) Flowers

Spittle bug (HOM., Cercopidae)	***Gliricidia sepium*** (Mother of cocoa)

b) Cones and seeds

Amblycerus scutellaris (COL., Bruchidae)	***Cordia alliodora*** (Cypre)
Conotrachelus sp. (COL., Curculionidae)	***Pinus caribaea*** (Caribbean pitch pine)
Dioryctria erythropasa (LEP., Pyralidae)	***Pinus caribaea*** (Caribbean pitch pine)
Dioryctria majorella (LEP., Pyralidae)	***Pinus caribaea*** (Caribbean pitch pine)
Leptoglossus sp. (HEM., Coreidae)	***Pinus caribaea*** (Caribbean pitch pine)
Megastigmus spp. (HYM., Torymidae)	***Pinus*** spp. (Pines)
Rhyacionia frustrana (LEP., Tortricidae)	***Pinus caribaea*** (Caribbean pitch pine)
Tetyra sp. (HEM., Pentatomidae)	***Pinus caribaea*** (Caribbean pitch pine)
Seed borer (LEP., unidentified)	***Caesalpinia velutina***

B. ROOTS

Phyllophaga spp. (COL., Scarabaeidae)	***Acacia mangium*** (Acacia), ***Bombacopsis quinatum*** (Saquisaqui), ***Cupressus lusitanica*** (Cypress), ***Gmelina arborea*** (Gmelina),

	Pinus caribaea (Caribbean pitch pine), ***Tectona grandis*** (Teak)

C. SEEDLINGS

Acheta assimilis (SALT., Gryllidae)	***Bombacopsis quinatum*** (Saquisaqui), ***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Agrotis ipsilon (LEP., Noctuidae)	***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** spp. (Eucalypts)
Agrotis spp. (LEP., Noctuidae)	***Bombacopsis quinatum*** (Saquisaqui), ***Cordia alliodora*** (Cypre), ***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Elasmopalpus lignosellus (LEP., Pyralidae)	***Bombacopsis quinatum*** (Saquisaqui)
Trigona silvestriana (HYM., Apidae)	***Pinus caribaea*** (Caribbean pitch pine)

D. BUDS AND SHOOTS

Rhyacionia frustrana (LEP., Tortricidae)	***Pinus caribaea*** (Caribbean pitch pine)
Rhyacionia subtropica (LEP., Tortricidae)	***Pinus*** spp. (Pines)
Trigona corvina (HYM., Apidae)	***Eucalyptus*** spp. (Eucalypts)

E. FOLIAGE

a) Exposed, chewing insects

Achyloides bursirus (LEP., Hesperiidae)	***Bombacopsis quinatum*** (Saquisaqui)

Arsenura armida (LEP., Saturniidae)	***Bombacopsis quinatum*** (Saquisaqui), ***Guazuma ulmifolia*** (Guacima).
Atta sp. (HYM., Formicidae)	***Acacia mangium*** (Acacia), ***Bombacopsis quinatum*** (Saquisaqui), ***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** spp. (Eucalypts), ***Gmelina arborea*** (Gmelina), ***Tectona grandis*** (Teak), ***Leucaena leucocephala*** (Leucaena), ***Pinus caribaea*** (Caribbean pitch pine)
Automeris rubrescens (LEP., Saturniidae)	***Cordia alliodora*** (Cypre), ***Guazuma ulmifolia*** (Guacima), ***Gmelina arborea*** (Gmelina)
Brachypnoea sp. (COL., Chrysomelidae)	***Acacia mangium*** (Acacia)
Brachypnoea sp. (COL., Chrysomelidae)	***Alnus acuminata*** (Alder)
Brachypnoea sp. (COL., Chrysomelidae)	***Cupressus lusitanica*** (Cypress)
Caio championi (LEP., Saturniidae)	***Bombacopsis quinatum*** (Saquisaqui)
Captocycla dorsoplagiata (COL., Chrysomelidae)	***Cordia alliodora*** (Cypre)
Captocycla leprosa (COL., Chrysomelidae)	***Cordia alliodora*** (Cypre)
Centrinaspis lineelus (COL., Curculionidae)	***Leucaena leucocephala*** (Leucaena)
Cropia phila (LEP., Noctuidae)	***Cordia alliodora*** (Cypre)
Charidotis vidreata (COL., Chrysomelidae)	***Cordia alliodora*** (Cypre)
Epitragus sp. (COL., Tenebrionidae)	***Guazuma ulmifolia*** (Guacima)

Erynnis sp. (LEP., Sphingidae)	***Gliricidia sepium*** (Mother of cocoa)
Eulepidotis sp. (LEP., Noctuidae)	***Bombacopsis quinatum*** (Saquisaqui)
Exophthalmus jekelianus (COL., Curculionidae)	***Cordia alliodora*** (Cypre), ***Cupressus lusitanica*** (Cypress), ***Pinus caribaea*** (Caribbean pitch pine), ***Eucalyptus*** spp. (Eucalypts)
Exophthalmus sp. (COL., Curculionidae)	***Cupressus lusitanica*** (Cypress)
Hylesia lineata (LEP., Saturniidae)	***Gliricidia sepium*** (Mother of cocoa), ***Guazuma ulmifolia*** (Guacima)
Hylesia sp. (LEP., Saturniidae)	***Cupressus lusitanica*** (Cypress), ***Pinus*** spp. (Pines)
Ledesmodina sp. (COL., Chrysomelidae)	***Guazuma ulmifolia*** (Guacima)
Lirimiris lignitecta (LEP., Notodontidae)	***Bombacopsis quinatum*** (Saquisaqui)
Lirimiris truncata (LEP., Notodontidae)	***Guazuma ulmifolia*** (Guacima)
Lonomia electra (LEP., Saturniidae)	***Gmelina arborea*** (Gmelina)
Mocis latipes (LEP., Noctuidae)	***Cordia alliodora*** (Cypre)
Neodiprion sp. (HYM., Diprionidae)	***Pinus*** spp. (Pines)
Nodonota irazuensis (COL., Chrysomelidae)	***Alnus acuminata*** (Alder), ***Cordia alliodora*** (Cypre), ***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Pantomorus strabo (COL., Curculionidae)	***Bombacopsis quinatum*** (Saquisaqui)

Periphoba arcaei (LEP., Saturniidae)	***Bombacopsis quinatum*** (Saquisaqui), ***Guazuma ulmifolia*** (Guacima)
Phelypera distigma (COL., Curculionidae)	***Guazuma ulmifolia*** (Guacima)
Polydacris sp. (COL., Curculionidae)	***Cordia alliodora*** (Cypre)
Schistocerca piceifrons (SALT., Acrididae)	***Bombacopsis quinatum*** (Saquisaqui), ***Gmelina arborea*** (Gmelina)
Selenothrips rubrocinctus (THYS., Thripidae)	***Eucalyptus*** spp. (Eucalypts)
Spodoptera sp. (LEP., Noctuidae)	***Gliricidia sepium*** (Mother of cocoa)
Trigona fuscipennis (HYM., Apidae)	***Acacia mangium*** (Acacia)
Skeletonizing larva (LEP., Arctiidae)	***Alnus acuminata*** (Alder)
Hairy larva (LEP., Arctiidae)	***Leucaena leucocephala*** (Leucaena)
Hairy larva (LEP., Arctiidae)	***Gliricidia sepium*** (Mother of cocoa)
Hairy larva (LEP., Arctiidae)	***Gliricidia sepium*** (Mother of cocoa)
Large-headed larva (LEP., Hesperiidae)	***Gliricidia sepium*** (Mother of cocoa)
Defoliating larva (LEP., Noctuidae)	***Gliricidia sepium*** (Mother of cocoa)
Bagworm (LEP., Psychidae)	***Cupressus lusitanica*** (Cypress)
Defoliating larva (LEP., Pyralidae)	***Gliricidia sepium*** (Mother of cocoa)
Skeletonizing larva (LEP., Tortricidae)	***Caesalpinia velutina***

Defoliating larva (LEP., Tortricidae)	***Leucaena leucocephala*** (Leucaena)
Chrysomelid beetle (COL., Chrysomelidae)	***Bombacopsis quinatum*** (Saquisaqui)

b) Gall - producing insects

Clinodiplosis sp. (DIPT., Cecidomyiidae)	***Cordia alliodora*** (Cypre)

c) Piercing - sucking insects

Acanalonia sp. (HOM., Acanaloniidae)	***Eucalyptus*** spp. (Eucalypts)
Aconophora ferruginea (HOM., Membracidae)	***Eucalyptus*** spp. (Eucalypts)
Aphis sp. (HOM., Aphididae)	***Eucalyptus*** spp. (Eucalypts)
Bolbonota inaequalis (HOM., Membracidae)	***Eucalyptus*** spp. (Eucalypts)
Ceresa concinna (HOM., Membracidae)	***Eucalyptus*** spp. (Eucalypts)
Cinara sp. (HOM., Aphididae)	***Pinus caribaea*** (Caribbean pitch pine)
Clastoptera sp. (HOM., Cercopidae)	***Eucalyptus*** spp. (Eucalypts)
Dictyla monotropidia (HEM., Tingidae)	***Cordia alliodora*** (Cypre)
Enchenopa lanceolata (HOM., Membracidae)	***Eucalyptus*** spp. (Eucalypts)
Graphocephala coccinea (HOM., Cicadellidae)	***Eucalyptus*** spp. (Eucalypts)
Graphocephala rufinago (HOM., Cicadellidae)	***Eucalyptus*** spp. (Eucalypts)

Hansenia pulverulenta (HOM., Flatidae)	***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Hesperopanthia championi (HOM., Flatidae)	***Leucaena leucocephala*** (Leucaena)
Heteropsylla cubana (HOM., Psyllidae)	***Leucaena leucocephala*** (Leucaena)
Hypselonotus atratus (HEM., Coreidae)	***Alnus acuminata*** (Alder), ***Cupressus lusitanica*** (Cypress)
Macunolla ventralis (HOM., Cicadellidae)	***Cordia alliodora*** (Cypre), ***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Micrutalis lugubrina (HOM., Membracidae)	***Eucalyptus*** spp. (Eucalypts)
Mozena sp. (HEM., Coreidae)	***Bombacopsis quinatum*** (Saquisaqui)
Onchometopia sp. (HOM., Cicadellidae)	***Eucalyptus*** spp. (Eucalypts), ***Leucaena leucocephala*** (Leucaena)
Paracarsidara sp. (HOM., Psyllidae)	***Bombacopsis quinatum*** (Saquisaqui)
Saissetia sp. (HOM., Coccidae)	***Eucalyptus*** spp. (Eucalypts)
Sphenorhina conspicua (HOM., Cercopidae)	***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Sibovia occatoria (HOM., Cicadellidae)	***Eucalyptus*** spp. (Eucalypts)
Umbonia crassicornis (HOM., Membracidae)	***Calliandra calothyrsus*** (Powderpuff)
Aphid (HOM., Aphididae)	***Gliricidia sepium*** (Mother of cocoa)
Spittle bug (HOM., Cercopidae)	***Calliandra calothyrsus*** (Powderpuff)

Spittle bug (HOM., Cercopidae)	***Gliricidia sepium*** (Mother of cocoa)

F.TRUNK AND BRANCHES

a) Cambium borers (Bark beetles)

Dendroctonus adjunctus (COL., Scolytidae)	***Pinus*** spp. (Pines)
Dendroctonus frontalis (COL., Scolytidae)	***Pinus*** spp. (Pines)
Dendroctonus spp. (COL., Scolytidae)	***Pinus*** spp. (Pines)
Ips spp. (COL., Scolytidae)	***Pinus*** spp. (Pines)
Scolytodes alni (COL., Scolytidae)	***Alnus acuminata*** (Alder)

b) Xylem borers

Chrysobothris sp. (COL., Buprestidae)	***Mimosa scabrella*** (Bracatinga)
Neoclytus cacicus (COL., Cerambycidae)	***Tectona grandis*** (Teak)
Neoclytus sp. (COL., Cerambycidae)	***Mimosa scabrella*** (Bracatinga)
Plagiohammus spinipennis (COL., Cerambycidae)	***Tectona grandis*** (Teak)
Platypus ca. ***godmani*** (COL., Platypodidae)	***Eucalyptus*** spp. (Eucalypts)
Platypus sp. (COL., Platypodidae)	***Acacia mangium*** (Acacia)
Steirastoma histrionicum (COL., Cerambycidae)	***Bombacopsis quinatum*** (Saquisaqui)

White larva (COL., Cerambycidae)	***Cordia alliodora*** (Cypre)
Bark beetle (COL., Scolytidae)	***Acacia mangium*** (Acacia)
Bark beetle (COL., Scolytidae)	***Mimosa scabrella*** (Bracatinga)
Red larva (LEP., Cossidae)	***Mimosa scabrella*** (Bracatinga)

c) Xylem and pith borers

Aepytus sp. (LEP., Hepialidae)	***Bombacopsis quinatum*** (Saquisaqui), ***Gmelina arborea*** (Gmelina), ***Guazuma ulmifolia*** (Guacima)
Coptotermes crassus (ISO., Rhinotermitidae)	***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** spp. (Eucalypts)
Boring larva (LEP., Hepialidae)	***Gmelina arborea*** (Gmelina)

d) Vectors

Ips spp. (COL., Scolytidae)	***Pinus*** spp. (Pines)
Platypus ca. ***dolabratus*** (COL., Platypodidae)	***Cupressus lusitanica*** (Cypress)
Platypus sp. (COL., Platypodidae)	***Cupressus lusitanica*** (Cypress)
Wood borer (COL., Platypodidae)	***Casuarina equisetifolia*** (Casuarina)

e) Bark chewers or girdlers

Leptostylus sp. (COL., Cerambycidae)	***Guazuma ulmifolia*** (Guacima)
Oncideres punctata (COL., Cerambycidae)	***Leucaena leucocephala*** (Leucaena)

Steirastoma histrionicum (COL., Cerambycidae)	***Bombacopsis quinatum*** (Saquisaqui)
Trigona corvina (HYM., Apidae)	***Pinus caribaea*** (Caribbean pitch pine)
Trigona cupira (HYM., Apidae)	***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Trigona ferricauda (HYM., Apidae)	***Eucalyptus*** spp. (Eucalypts), ***Pinus caribaea*** (Caribbean pitch pine)
Trigona silvestriana (HYM., Apidae)	***Acacia mangium*** (Acacia), ***Casuarina equisetifolia*** (Casuarina), ***Pinus*** spp. (Pines), ***Cordia alliodora*** (Cypre), ***Eucalyptus*** spp. (Eucalypts)

f) Insects causing damage through oviposition

Cicada (HOM., Cicadidae)	***Guazuma ulmifolia*** (Guacima), ***Leucaena leucocephala*** (Leucaena)

VERTEBRATES

A. REPRODUCTIVE PARTS

Aratinga canicularis (AVES., Psittacidae) (Orange-fronted parakeet)	***Gmelina arborea*** (Gmelina seeds)

B. ROOTS

Orthogeomys spp. (ROD., Geomyidae) (Pocket gophers)	***Bombacopsis quinatum*** (Saquisaqui), ***Tectona grandis*** (Teak), ***Cupressus lusitanica*** (Cypress), ***Gliricidia sepium*** (Mother of cocoa), ***Gmelina arborea*** (Gmelina), ***Pinus*** spp. (Pines), ***Eucalyptus*** spp. (Eucalypts)

C. SEEDLINGS AND STUMPS

Alouatta palliata (PRI., Cebidae) (Howler monkey)	***Bombacopsis quinatum*** (Saquisaqui)
Basiliscus basiliscus (SAU., Iguanidae) (Jesus Christ lizard)	***Cordia alliodora*** (Cypre), ***Gmelina arborea*** (Gmelina)
Ctenosaura similis (SAU., Iguanidae) (Ctenosaur)	***Bombacopsis quinatum*** (Saquisaqui)
Dasypus novemcinctus (EDE., Dasypodidae) (Armadillo)	***Acacia mangium*** (Acacia), ***Cordia alliodora*** (Cypre), ***Cupressus lusitanica*** (Cypress), ***Gmelina arborea*** (Gmelina), ***Pinus caribaea*** (Caribbean pitch pine)
Odocoileus virginianus (ART., Cervidae) (White-tailed deer)	***Bombacopsis quinatum*** (Saquisaqui)
Orthogeomys cherriei (ROD., Geomyidae) (Pocket gopher)	***Bombacopsis quinatum*** (Saquisaqui), ***Gliricidia sepium*** (Mother of cocoa)

Orthogeomys heterodus (ROD., Geomyidae) (Pocket gopher)	***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** spp. (Eucalypts), ***Pinus*** spp. (Pines)
Orthogeomys underwoodi (ROD., Geomyidae) (Pocket gopher)	***Tectona grandis*** (Teak)
Sylvilagus brasiliensis (LAG., Leporidae) (Rabbit)	***Cordia alliodora*** (Cypre), ***Gmelina arborea*** (Gmelina)
Sylvilagus floridanus (LAG., Leporidae) (Rabbit)	***Alnus acuminata*** (Alder)
Tayassu tajacu (ART., Tayassuidae) (Collared peccary)	***Bombacopsis quinatum*** (Saquisaqui)

D. BUDS AND SHOOTS

Aratinga canicularis (AVES., Psittacidae) (Orange-fronted parakeet)	***Gmelina arborea*** (Gmelina)

E. FOLIAGE

Alouatta palliata (PRI., Cebidae) (Howler monkey)	***Gmelina arborea*** (Gmelina)
Aratinga canicularis (AVES., Psittacidae) (Orange-fronted parakeet)	***Gmelina arborea*** (Gmelina)

F. TRUNK AND BRANCHES (Bark removal)

Coendou mexicanum (ROD., Erethizontidae) (Prehensile-tailed porcupine)	***Gmelina arborea*** (Gmelina)
Dasyprocta punctata (ROD., Dasyproctidae) (Agouti)	***Acacia mangium*** (Acacia)

Sciurus granatensis (ROD., Sciuridae) (Squirrel)	***Cupressus lusitanica***
Sciurus variegatoides (ROD., Sciuridae) (Squirrel)	***Bombacopsis quinatum*** (Saquisaqui), ***Eucalyptus*** spp. (Eucalypts)
Sigmodon hispidus (ROD., Cricetidae) (Hispid cotton rat)	***Acacia mangium*** (Acacia), ***Bombacopsis quinatum*** (Saquisaqui), ***Gmelina arborea*** (Gmelina)

PATHOGENS

A. REPRODUCTIVE PARTS (Seeds)

Cladosporium sp.	*Cordia alliodora* (Cypre)
Fusarium sp.	*Alnus acuminata* (Alder)
Trichoderma sp.	*Alnus acuminata* (Alder)

B. ROOTS

Corticium sp.	*Eucalyptus* spp. (Eucalypts)
Cylindrocladium sp.	*Bombacopsis quinatum* (Saquisaqui)
Diplodia sp.	*Eucalyptus* sp. (Eucalypt)
Fusarium oxysporum	*Gliricidia sepium* (Mother of cocoa), *Tectona grandis* (Teak)
Fusarium solani	*Bombacopsis quinatum* (Saquisaqui)
Fusarium sp.	*Casuarina equisetifolia* (Casuarina), *Leucaena leucocephala* (Leucaena), *Pinus* sp. (Pine)
Phytophthora sp.	*Eucalyptus* sp. (Eucalypt), *Pinus* sp. (Pine)
Rhizoctonia solani	*Acacia mangium* (Acacia), *Casuarina equisetifolia* (Casuarina), *Pinus* sp. (Pine)
Rosellinia sp.	*Alnus acuminata* (Alder), *Bombacopsis quinatum* (Saquisaqui), *Gmelina arborea* (Gmelina), *Pinus* sp. (Pine)

C. FOLIAGE

Alternaria sp.	*Cupressus lusitanica* (Cypress)
Asperisporium sequoiae	*Cupressus lusitanica* (Cypress)

Aulographina eucalypti	***Eucalyptus*** spp. (Eucalypts)
Botryodiplodia sp.	***Acacia mangium*** (Acacia)
Botrytis sp.	***Eucalyptus*** sp. (Eucalypt)
Cercospora pinea	***Pinus*** sp. (Pine)
Cladosporium sp.	***Acacia mangium*** (Acacia), ***Cordia alliodora*** (Cypre)
Colletotrichum sp.	***Alnus acuminata*** (Alder), ***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** sp. (Eucalypt), ***Gliricidia sepium*** (Mother of cocoa), ***Gmelina arborea*** (Gmelina)
Corynespora sp.	***Tectonis grandis*** (Teak)
Cylindrocladium scoparium	***Eucalyptus*** sp. (Eucalypt)
Cylindrocladium sp.	***Eucalyptus*** sp. (Eucalypt) ***Gliricidia sepium*** (Mother of cocoa)
Diplodia sp.	***Eucalyptus*** spp. (Eucalypts), ***Pinus*** sp. (Pine)
Dothistroma septospora	***Pinus*** sp. (Pine)
Lophodermium sp.	***Pinus*** sp. (Pine)
Pestalotia sp.	***Acacia mangium*** (Acacia), ***Casuarina equisetifolia*** (Casuarina), ***Cupressus lusitanica*** (Cypress), ***Eucalyptus*** sp. (Eucalypt) ***Gliricidia sepium*** (Mother of cocoa)
Phoma sp.	***Gliricidia sepium*** (Mother of cocoa)
Phomopsis sp.	***Alnus acuminata*** (Alder), ***Casuarina equisetifolia*** (Casuarina), ***Gmelina arborea*** (Gmelina)
Pleospora sp.	***Pinus*** sp. (Pine)
Pseudocercospora rangita	***Gmelina arborea*** (Gmelina)
Pseudoseptoria sp.	***Eucalyptus*** sp. (Eucalypt)

Puccinia sp.	*Acacia mangium* (Acacia)
Seiridium cardinale	*Cupressus lusitanica* (Cypress)
Uredo sp.	*Cordia alliodora* (Cypre)

D. TRUNK AND BRANCHES

Agrobacterium tumefasciens	*Eucalyptus* sp. (Eucalypt), *Tectona grandis* (Teak)
Aulographina eucalypti	*Eucalyptus* sp. (Eucalypt)
Botryosphaeria ribis	*Eucalyptus* sp. (Eucalypt)
Colletotrichum dematium	*Bombacopsis quinatum* (Saquisaqui)
Colletotrichum sp.	*Leucaena leucocephala* (Leucaena)
Corticium salmonicolor	*Eucalyptus* sp. (Eucalypt)
Cronartium sp.	*Pinus* sp. (Pine)
Cryphonectria cubensis	*Eucalyptus* sp. (Eucalypt)
Cylindrocladium sp.	*Bombacopsis quinatum* (Saquisaqui)
Diplodia sp.	*Eucalyptus* sp. (Eucalypt) *Pinus* sp. (Pine)
Erwinia sp.	*Acacia mangium* (Acacia)
Fusarium oxysporum	*Bombacopsis quinatum* (Saquisaqui), *Gliricidia sepium* (Mother of cocoa)
Fusarium solani	*Bombacopsis quinatum* (Saquisaqui)
Fusarium sp.	*Acacia mangium* (Acacia), *Leucaena leucocephala* (Leucaena)
Phomopsis salmonica	*Bombacopsis quinatum* (Saquisaqui)
Phomopsis sp.	*Casuarina equisetifolia* (Casuarina), *Gmelina arborea* (Gmelina)
Poria sp.	*Pinus* sp. (Pine)

Rosellinia sp.	***Bombacopsis quinatum*** (Saquisaqui), ***Gmelina arborea*** (Gmelina)
Scytalidium sp.	***Bombacopsis quinatum*** (Saquisaqui)
Verticillium sp.	***Bombacopsis quinatum*** (Saquisaqui)
Xanthomonas sp.	***Cordia alliodora*** (Cypre)

PARASITIC PLANTS

Arceuthobium vaginatum	***Pinus*** sp. (Pine)
Oryctanthus alveolatus	***Caesalpinia velutina***
Struthanthus leptostachyus	***Acacia mangium*** (Acacia)
Struthanthus orbicularis	***Casuarina equisetifolia*** (Casuarina)
Struthanthus quercicola	***Calliandra calothyrsus*** (Powderpuff)

MONOGRAPHS
CHAPTER II

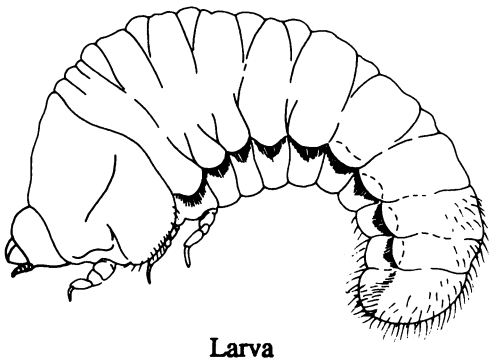
1. INSECTS

ORDER COLEOPTERA

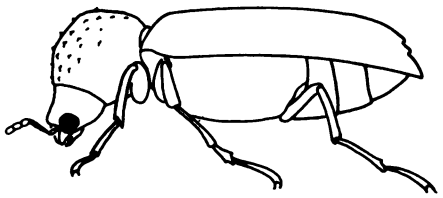
FAMILY BOSTRICHIDAE

The adults have a somewhat cylindrical, elongated body measuring between 3 and 20 mm. The head points downwards and can barely be seen dorsally. The pronotum has a rough appearance with several tubercles or tiny teeth. The larva is "C" shaped with an expanded thoracic section. They attack both living trees and dead branches or seasoned wood. The adults make deeply penetrating galleries in the branches. The larvae feed on dry wood and pupate in the galleries made by the adults. In living trees, the damage retards growth and deforms the trunk. It causes drying and makes the trunk liable to break in high winds

In Caribbean countries, ***Apate monachus*** attacks living ***Casuarina equisetifolia***, ***Swietenia mahagoni***, ***S. macrophylla*** and ***Melia azederach***, causing retarded growth, deformation and breaking. This species, along with ***Apate terebrans***, occurs in Ghana, Nigeria and Zambia. In Brazil, ***Micrapate brasiliensis*** attacks ***Schizolobium excelsum***. In Asia and Africa there are six species of the genera ***Heterobostrychus***, ***Xilothrips*** and ***Sinoxylon*** which attack dry or seasoned wood and forestry products.



Larva



Adult

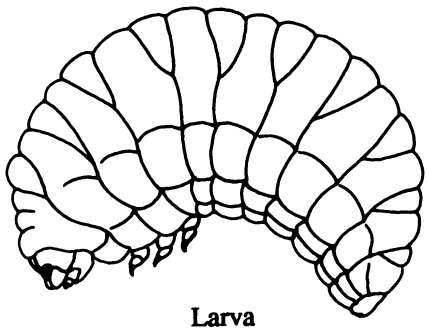
References: GALLO *et al.*, 1978

FAMILY BRUCHIDAE

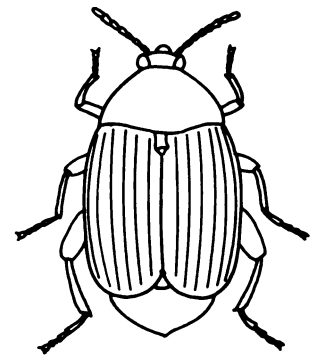
The adults are small, generally measuring less than 5 mm, with a compact body and short elytra (thickened anterior wings), which do not completely cover the abdomen. The head is prolonged anteriorly to form a somewhat thickened proboscis. The female lays eggs on flowers, young fruit or developed seeds, where the larva completes its development, destroying the interior. To emerge from the seed, the adult makes a round hole in the surface.

In Costa Rica it has been reported that ***Mimosetes nubigens*** attacks ***Acacia farnesiana*** pods, ***Amblycerus*** ca. ***scutellaris*** attacks the seeds of ***Cordia alliodora***, ***Merobruchus columbinus*** and ***Stator limbatus*** feed on the seeds of ***Pithecellobium saman*** and ***Stator generalis*** feed on those of ***Enterolobium cyclocarpum.***

In Caribbean countries, ***Amblycerus pygidialis*** attacks seeds of ***Cordia gerascanthus*** and ***Luehea speciosa.*** In Sudan, ***Bruchus baudoni*** attacks seeds of ***Acacia arabica.***



Larva



Adult

References: FORD, 1981; JANZEN, 1983a.

FAMILY BUPRESTIDAE

The adults have an elongated, oval body between 3 and 100 mm in length. The downwardly directed head appears to be included in the prothorax. The coloration is variable, often with a metallic appearance. The larvae generally have an expanded, flattened anterior end (head and thorax), similar to cerambycid larvae but with the anterior extreme more flattened. They may also be distinguished by the presence of shields or plates on the dorsal and ventral surfaces, an upside down "V" shaped suture or mark on the dorsal surface of the prothorax and half moon shaped spiracles.

The larvae bore beneath the bark or penetrate the wood of living trees as well as old or recently cut logs. The female makes cracks in the bark to lay eggs. On emergence, the larvae bore through the bark. Some species construct twisting galleries just under the bark. These contain a mixture of sawdust and excrement and the larvae complete development here. Others construct galleries deeper in the wood or xylem.

In Costa Rica, ***Chrysobothris*** sp. has been reported attacking the xylem of ***Mimosa scabrella*** and another, unidentified species, the xylem of ***Bombacopsis quinatum.***

In Asia and the Pacific, ***Agrilus kalshoveni*** has been reported to attack living ***Actinophora fragans***, ***Agporilus*** sp. to attack ***Eucalyptus deglupta*** and ***Chrysochroa*** sp. to attack ***Mesua ferra*** and ***Poeciloneuron indicum.***

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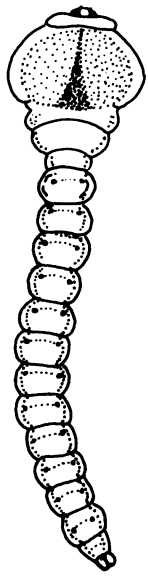
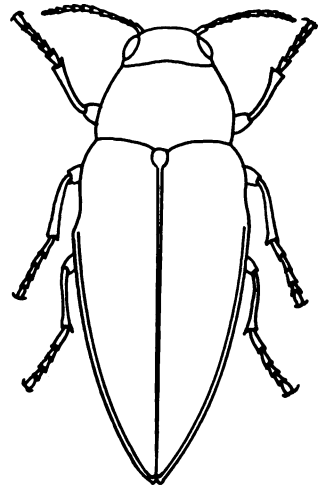
FAMILY BUPRESTIDAE



Larva



Adult

FAMILY CERAMBYCIDAE

The adults have elongated, cylindrical bodies measuring between 3 and 200 mm. in length, with long antennae which sometimes exceed the length of the body. The female makes cracks in the bark for egg laying. On emergence, the larvae bore through the bark and construct galleries between it and the wood, or deeper in the wood itself. Some species attack weakened trees or recently cut logs while others attack branches, removing a ring or band of bark above which they deposit their eggs. The larvae are elongated, cylindrical, whitish and almost apodal (without legs). The anterior (head and thorax) is rounded and bulging, distinguishing them from the Buprestidae; furthermore, the spiracles are circular and the shield or plate occurs only on the dorsum.

In Costa Rica the most important species are the borers ***Plagiohammus spinipennis*** in ***Tectona grandis*** and ***Steirastoma histrionicum*** in ***Bombacopsis quinatum***. Other xylem borers include ***Neoclytus cacicus*** in ***Tectona grandis***, ***Neoclytus*** sp. in ***Mimosa scabrella***, ***Aneflus*** sp. in ***Pithecellobium saman***, ***Achryson surinamum*** in ***Dalbergia sissoo*** and ***Brasilianus mexicanus*** in ***Astronium graveolens***. Adults of ***Oncideres punctata*** "saw" or girdle the trunks of ***Leucaena leucocephala***, ***Pithecellobium saman*** and ***Albizzia guachapele***. An unidentified species does similar damage to ***Cordia alliodora*** in Costa Rica and ***Leptostylus*** sp. to ***Guazuma ulmifolia*** in Panama.

In some Caribbean countries, ***Neoclytus cordifer*** attacks ***Casuarina equisetifolia***. ***Chlorida festiva*** attacks the same species and also ***Eucalyptus citriodora***, ***Albizzia lebbek*** and ***Mangifera indica***. ***Acanthoderes circumflexa*** and ***Plectomerus dentipes*** attack ***Swietenia mahagoni*** and ***Hibiscus*** sp. and ***Stizocera insulana*** attacks ***Tabebuia angustata***. In Brazil, ***Achryson surinamum*** and ***Stenodontes spinibarbis*** attack ***Eucalyptus*** spp., ***Neoclytus pusillus*** attacks ***Acacia decurrens***, ***Acanthoderes jaspidea*** attacks ***Schizolobium parahybum*** and ***Oncideres impluviata*** and ***O. dejeani*** respectively girdle ***Acacia decurrens*** and ***Casuarina cunninghamiana***. In Bolivia, ***Pteroplata*** cf. ***adustus*** attacks ***Eucalyptus*** spp. In India, ***Celosterna scabrator*** attacks ***Tectona grandis*** and ***Gmelina arborea***. In India and Pakistan, ***Hoplocerambyx spinicornis*** attacks ***Shorea robusta***; in Malaysia it attacks ***Shorea resinanigra*** and in Zaire, ***Monochamus scabiousus*** attacks ***Maesopsis eminii***.

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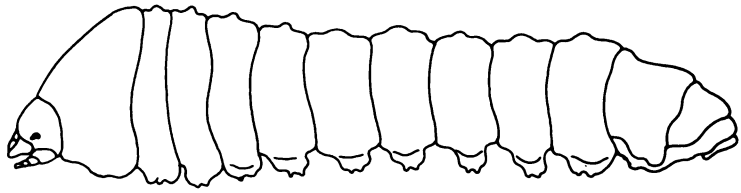
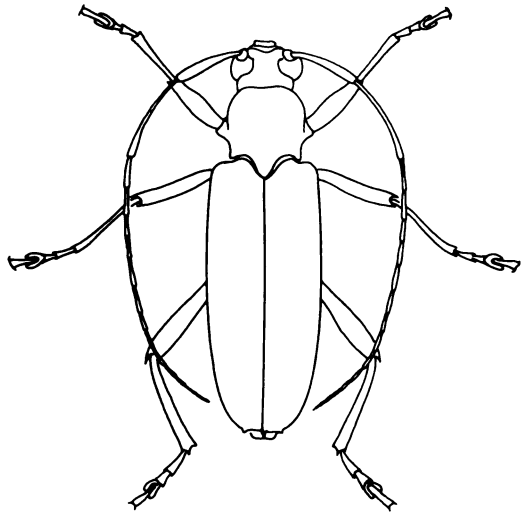
FAMILY CERAMBYCIDAE



Larva



Adult

References: DUFFY, 1960; GALLO *et al.*, 1978; NAIR, 1986.

Plagiohammus spinipennis

The larva of this beetle attacks the trunk of teak (***Tectona grandis***). During the first instars, the larvae apparently feed in the phloem region, obstructing the flow of hormones and nutrients. Bulging or inflammation occurs at the site of attack, and buds producing branching emerge from below this point. Later, the larva bores into the xylem, where it constructs horizontal galleries leading to the pith. From here it tunnels upwards for sometimes more than 20 cm. The attack on the xylem not only affects the quality of the wood, but it can also create a weak point in the tree where bifurcation and even subsequent breakage can occur. However, it is interesting to note that some trees may exhibit up to three bulges without suffering breaks.

Damage may be seen in trees with a 2 cm diameter and those much older. Bulges have been seen in trees whose height varies from 0.5 to 15 m. However, damage seems greatest during the first three years when the trees are between 3 and 5 m in height. There seems to be greater incidence in wet zones and where there are abundant weeds. Two alternative hosts have been found: the shrub ***Vernonia patens*** and a herbaceous plant ***Lantana camara.***

The mature larva can measure over 5 cm and has a typical cerambycid shape. The prothoracic plate is large and deep yellow in color. It pupates inside a cell excavated in the pith and surrounding wood. To emerge from the tree, the adult makes a circular hole, 6-8 mm in diameter. It is not known whether there is more than one generation per year.

The adult male measures 2.2 cm with 4.5 cm long antennae. The female is 2.5 cm long with 3.5 cm antennae. Both sexes are dark brown with two white lines associated with the spines of the pronotum and six irregular white spots on the elytra (four lateral and two central). There is a spine at the apex of each of the elytra. In the laboratory, an adult can survive fifteen days with only water and no food.

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Plagiohammus spinipennis

Larva

Adult

Damage

References: FORD, 1981.

Steirastoma histrionicum

This insect can cause serious problems both as an adult and as a larva attacking the trunk of ***Bombacopsis quinatum***. It has also been observed attacking ***Ceiba pentandra*** and ***Sterculia apetala***.

The adults cause considerable losses in very young trees by chewing the bark. Damage is most severe during the dry season when, through lack of water, they may be forced to feed on succulent plant tissue resulting in the drying and death of the trees.

The mature larva has a characteristic cerambycid shape and may measure more than 4.5 cm. The prothoracic plate is discontinuous and pale yellow. During the first instars, the larva feeds under the bark, on the periphery of the xylem, forming wide flat galleries up to 4 mm deep. These galleries not only affect the wood, but they create weak points where the tree may subsequently break. Older larvae perforate the xylem and pith, pupating in the pith and adjacent wood. To emerge from the tree, the adult makes an elliptical hole, 20 x 11 mm in diameter.

The adult measures 2.2-3 cm in length with antennae 2-3.5 cm long, as long or longer than the body. The femurs are slightly thickened and the front tarsi elongated. The pronotum is rough and irregular with three dorsal ridges and several lateral tubercles or protuberances. The base of the elytra is wider than the apex and also has small protuberances. A prominent ridge, curved at the base and then straight, with noticeable tubercles, arises in this region. The head, prothorax and elytra are black with reddish markings. On the elytra the markings are linear so that the insects appear to have alternating red and black bands.

There is no information to date on the species' life cycle except that the pupal stage lasts less than a month.

The insect has been seen attacking ***Bombacopsis quinatum*** trees of up to six years old.

Of species taxonomically related to *S.* ***histrionicum***, *S.* ***melanogenys*** attacks ***Theobroma cacao*** in Costa Rica. In other tropical Latin American countries, *S.* ***breve*** attacks ***Theobroma cacao***,

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Cocos nucifera and several species of the genera ***Pachira***, ***Ceiba***, ***Bombax***, ***Sterculia***, ***Hibiscus***, ***Chorisia***, ***Eucalyptus***, ***Erythrina***, ***Couroupito***, ***Wistaria***, ***Salix***, ***Eriodendron*** and ***Malachra***. ***S. marmoratum*** attacks ***Mangifera indica***, ***Araucaria angustifolia*** and other forest species. ***S. stellio*** attacks several species of ***Acacia*** and other genera. ***S. meridionale*** attacks ***Chorisia*** sp.

Larva

Adult

Damage caused by larvae

Damage caused by adult

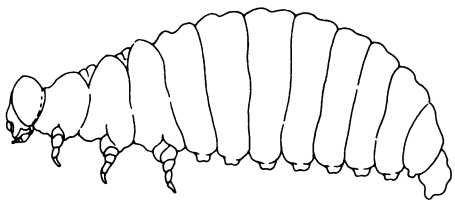
References: DUFFY, 1960; LARA, 1961.

FAMILY CHRYSOMELIDAE

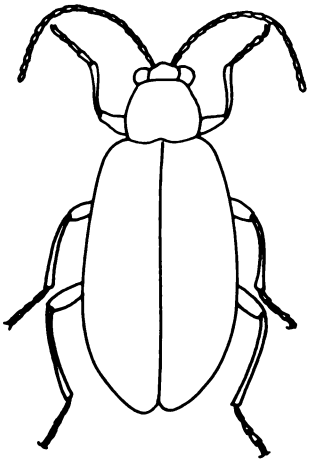
This is a large family and consequently difficult to characterize. In general, the adults have an oval, convex body, 1-25 mm in length, often brilliantly colored. They feed on leaves and flowers. The larvae may feed on leaves externally, mine them, feed on roots or bore into stems.

In Costa Rica, adult ***Nodonota irazuensis***, which also attack beans, defoliate ***Alnus acuminata***, ***Eucalyptus deglupta*** and ***Terminalia ivorensis***. Larvae and adults of ***Charidotis vidreata***, ***Captocycla dorsoplagiata*** and ***C. leprosa*** defoliate ***Cordia alliodora***. ***Brachypnoea*** spp. are common on ***Acacia mangium***, Alnus acuminata and ***Cupressus lusitanica***. ***Tabebuia rosea*** is defoliated by ***Akantada insidiosa*** and ***Longitarsus*** sp. In Panama, ***Ledismodina*** sp. defoliates ***Guazuma ulmifolia***.

In some Caribbean countries, larvae and adults of ***Paratrikona lerouxi*** defoliate ***Tabebuia pentaphylla*** and ***T. augustata***. In India and Burma, ***Calopepla leayana*** defoliates ***Gmelina arborea***.



Larva



Adult

References: FORD, 1981; KING & SAUNDERS, 1984; NAIR, 1986.

FAMILY CURCULIONIDAE

These insects are known as snout beetles since the head is prolonged into a snout or rostrum, with antennae situated halfway along the length. Size, along with coloration, is very variable, between 1 and 35 mm. They are almost without exception plant feeders. They can consume any plant part, although the larvae generally live within the tissue, whilst the adults perforate fruits and nuts and eat other plant parts.

In Costa Rica, adult ***Exophthalmus jekelianus***, as well as attacking several agricultural crops, feed on leaves of ***Cordia alliodora*** along with ***Polydacrys*** sp. A different species of ***Exophthalmus*** attacks ***Bombacopsis quinatum*** and ***Centrinaspis lineelus*** attacks ***Leucaena leucocephala.*** Three species of ***Anthonomus*** attack ***Hymenaea courbaril*** buds and ***Rhinochenus transversalis*** and ***R. stigma*** its seeds. Larvae and adults of ***Phelypera distigma*** defoliate ***Guazuma ulmifolia*** in Costa Rica and Panama. In Honduras, ***Conotrachelus*** sp. damages the cones of various species of ***Pinus.***

In Caribbean countries, adults of ***Lachnopus*** sp. and ***Exophthalmus hybridus*** feed on pine needles and the larvae attack the roots. ***Pachnaeus litus*** adults defoliate ***Swietenia mahagoni*** and ***S. macrophylla*** and ***Euscelus aureolus*** adults defoliate ***Eucalyptus*** spp. ***Apion martinezi*** attacks fruit and seeds of ***Zanthoxylum flavum.*** In Africa and Asia, ***Gonipterus scutellatus*** defoliates ***Eucalyptus*** spp., ***Pagiophloeus longiclavis*** bores into ***Swietenia mahagoni*** and ***Nanophyes*** sp. destroys the fruits of ***Terminalia ivorensis.***

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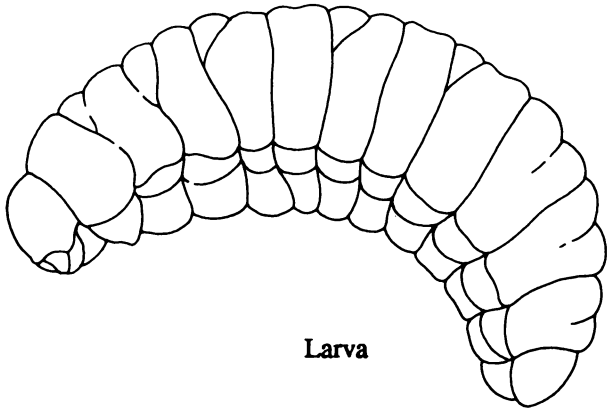
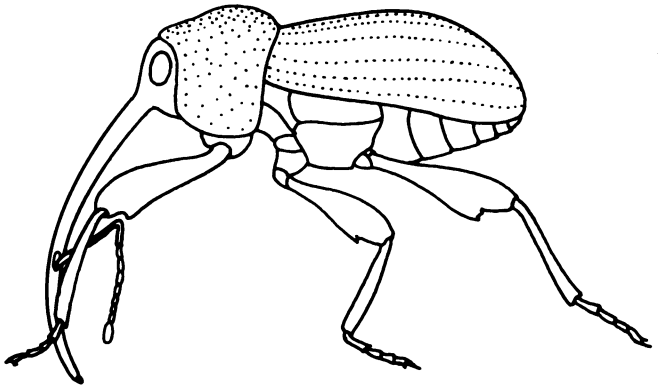
FAMILY CURCULIONIDAE



Larva



Adult

References: CARLIN & NUÑEZ, 1985; FORD, 1981; JANZEN, 1983a; KING & SAUNDERS, 1984.

The mature larva measures approximately 1 cm. It has a black head and yellow body with black protuberances and several long, black hairs. The larvae are gregarious and it is not unusual to find a group at rest with the heads pointing outwards.

Eclosion of the egg takes two weeks. During the first two weeks, the larvae feed on the undersides of young ***Guazuma ulmifolia*** leaves, starting with the lamina and then destroying them completely. When the larva is mature, it spins a sphere of very white thread inside which it pupates. This stage lasts between three and five days. Groups of up to fifteen spheres can often be seen stuck together. Inside each sphere there is a naked, yellow pupa with visible beak-shaped mouthparts. The adult is a 1 cm long weevil, brick-red in color, with a medium sized, black mark in the center of each of the elytra and several smaller marks. Towards the posterior end of the elytra is a protuberance in the form of a spine. The adults feed on foliage for two weeks, change color to light brown and disappear for the rest of the year. The period of greatest activity has been observed to be the middle of May in Costa Rica and the end of June in Panama. During these periods, some trees may have up to one thousand groups of pupal spheres.

Little is known of ***P. distigma***'s natural enemies, the only one reported being an unidentified fly from the Tachinidae family.

The geographic distribution of this species extends from Mexico to Colombia

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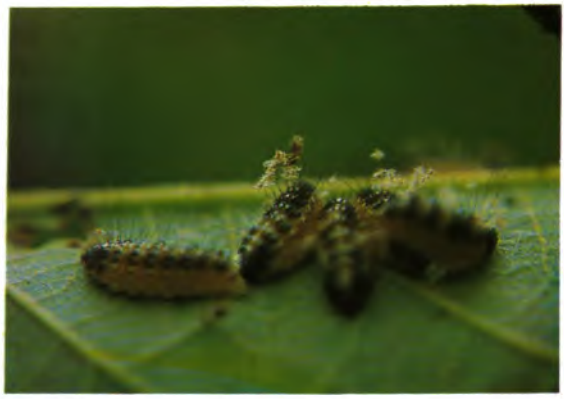
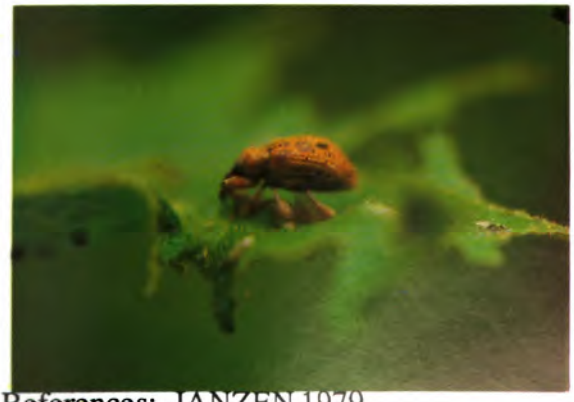
Phelypera distigma



Larva

Pupa



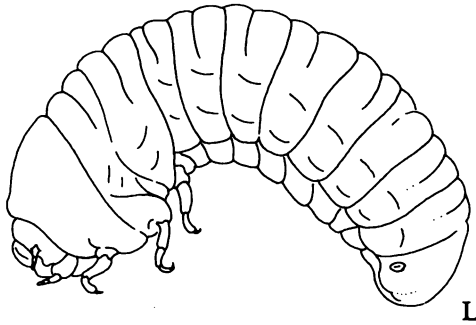
Adult

References: JANZEN,1979

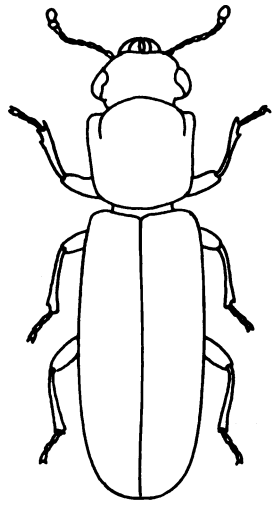
FAMILY LYCTIDAE

These are very small beetles measuring between 2 and 7 mm, dark brown or black, with a thin, elongated body. The head shows a slight constriction or narrowing behind the eyes.

Both larvae and adults feed on dry and seasoned wood. They destroy furniture and floors, for example, producing a fine dust. Damage can be detected by the presence of tiny holes, usually associated with the expulsion of fine powder.



Larva



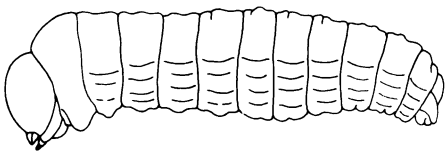
Adult

FAMILY PLATYPODIDAE

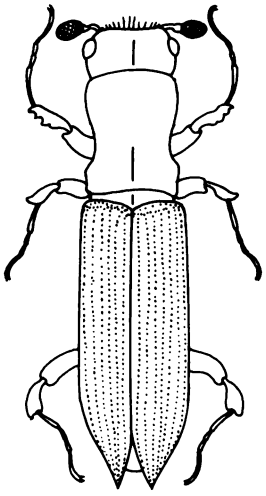
These are long, thin, cylindrical beetles with the head slightly wider than the pronotum. They are dark brown or black and between 4 and 6 mm in length. The tarsi are very thin and their first segment is longer than the total length of the other segments. They live in trees, feeding on fungi which the adults cultivate in galleries constructed in the wood or xylem. Although they attack living trees, they are more often found in less vigorous or weakened trees.

In Costa Rica, ***Platypus*** ca. ***godmani*** has been observed to attack ***Eucalyptus deglupta*** and ***P.*** ca. ***dolabratus*** and ***Platypus*** sp. to attack ***Cupressus lusitanica.*** ***Platypus*** sp. attacks ***Acacia mangium*** in Costa Rica, Panama and Honduras. In both Costa Rica and Guatemala, an unidentified species occurs in ***Casuarina equisetifolia.*** ***P. parallelus*** attacks ***Terminalia ivorensis***, its galleries penetrating through to the pith of the tree; it carries a fungus which grows in the vascular tissues and obstructs them.

In some Caribbean countries, ***Platypus poeyi*** and ***P. linearis*** attack some species of ***Pinus*** and several broadleaf species.



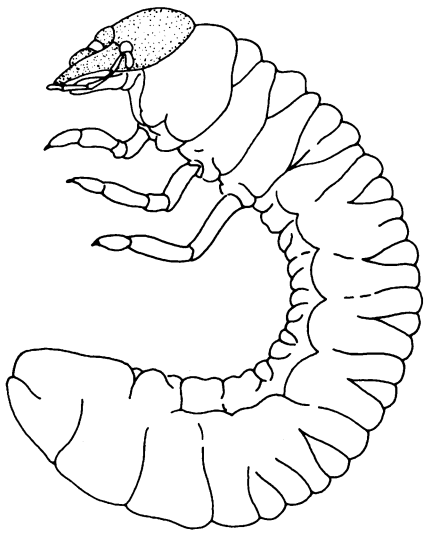
Larva



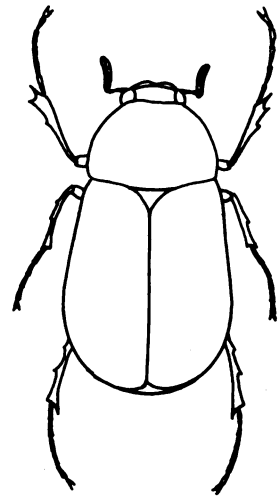
Adult

FAMILY SCARABAEIDAE

This is a very large family with a wide range of sizes, colors and habits. The adults' body is compact, oval or elongated and generally convex. From the forestry point of view, the most important species are the white grubs or larvae of June beetles (***Phyllophaga*** spp.)



Larva



Adult

Phyllophaga spp.

In Central America there are 28 species of these beetles whose larvae are known as white grubs and whose adults are known as June beetles. Although the adults only appear for a few weeks at the beginning of the rainy season, the larvae spend almost all the year under the soil surface. It is believed that some species have an annual life cycle whilst for others it lasts two years. The first type have one generation per year, the others one generation every two years. Females of ***Phyllophaga menetriesi***, for example, may produce up to 200 eggs which are laid between 2 and 10 cm deep in the soil. The "C" shaped larva passes through three instars. During the first two instars (four to six weeks) they feed on organic matter and fibrous roots, whilst the third instar larva (five to eight weeks) feeds exclusively on roots. The larva then constructs a cell between 10 and 20 cm deep in the soil, where it remains inactive until January or February, which is the pupation period.

Although the adults feed on the leaves of ***Erythrina poeppigiana***, ***Hibiscus*** spp., ***Anona*** sp. and ***Ceiba*** sp., most damage is caused by the third instar larvae which feed on the roots of many species of agricultural interest, causing wilting and drying. Amongst forest species, they can cause considerable losses since the larvae consume the secondary roots and bark of the main root leading to the death of seedlings and saplings of, for example, ***Acacia mangium***, ***Cupressus lusitanica***, ***Albizzia guachapele***, ***Gmelina arborea***, ***Pinus caribaea***, ***Bombacopsis quinatum***, ***Astronium graveolens*** and ***Tectona grandis***.

Larva

Adult

References: KING & SAUNDERS, 1984.

FAMILY SCOLYTIDAE

These are small cylindrical beetles which rarely measure more than 6 to 8 mm. They are dark brown or black and feed on the inside of the bark or the wood of certain trees. There are two types of scolytid, the bark beetles and the fungus carriers, although some species exhibit both habits.

The bark beetles live under the bark and both adults and larvae attack the wood or xylem surface. The adults enter the tree and tunnel one or several galleries. Eggs are laid in small grooves located at regular intervals in the walls. These breeding galleries may be constructed by a single pair or by one male with two or more females, each one of which builds a gallery. The appearance of the galleries varies according to species. When the eggs hatch, the larvae construct individual tunnels which radiate from the main gallery and grow larger as the larva grows in size. Each larva completes its development and pupates at the end of its tunnel. On emergence, the adult beetle bores through the bark to emerge, leaving a small, round exit hole resembling a tiny pellet hole. Some bark beetles attack dead or recently cut trunks whilst others attack living trees and can cause their death.

The fungus carriers or "ambrosia beetles" do not feed on the wood of the trees, but on the fungi that they cultivate in the galleries. These are very deep and penetrate the wood or xylem. When there are many of them, they can cause serious problems. The larvae develop inside small cells contiguous with the main gallery and, in the majority of species, are fed by adult females who continually renew the fungus and remove fecal matter. Generally speaking, each species feeds on a specific type of fungus. When a recently emerged female flies to another tree to colonize it, she takes conidia of the fungus with her to "sow" in the new galleries. The fungi belong to several genera, amongst the most notable being ***Ceratocystis***. In recent years, it has been shown that some mites of the family Tarsonemidae, living on some species of ***Dendroctonus*** and ***Ips***, may also transport fungi.

In Guatemala and Honduras, several species of ***Pinus*** are attacked by six species of ***Dendroctonus*** and three of ***Ips***. The cones are attacked by ***Conophthorus***. In Costa Rica, ***Scolytodes alni*** affects ***Alnus acuminata*** and three unidentified species attack ***Acacia mangium***, ***Mimosa scabrella*** and ***Terminalia ivorensis***.

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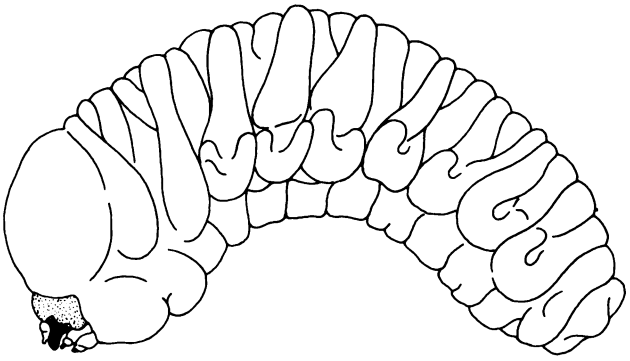
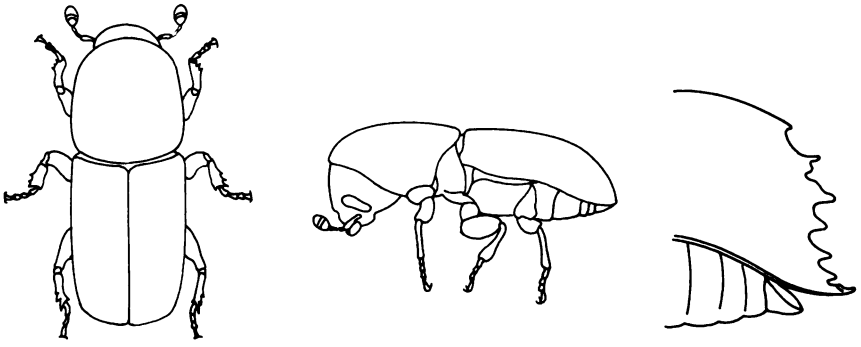
FAMILY SCOLYTIDAE

In some Caribbean countries, the most important species are ***Ips interstitialis***, ***I. grandicollis***, ***Xyleborus affinis*** and ***Hypothenemus eruditus*** affecting conifers and ***Neodryocetes devius*** affecting ***Calophyllum brasiliensis***.



Larva



Adult

References: MOSER, 1985; WOOD, 1982.

Dendroctonus spp.

Six species of ***Dendroctonus*** have been reported in Central America: ***D. frontalis***, ***D. adjunctus***, ***D. approximatus***, ***D. valens***, ***D. parallelocolis*** and ***D. vitei***. They all attack species of ***Pinus***. Several of these species also occur in Mexico and the United States.

They are dark brown or black, measuring 3-8 mm with a convex posterior end. They colonize live trees, generally those weakened by climatic or edaphic factors. Their effect is extremely damaging since they obstruct the passage of water and nutrients in the phloem. As a result, the tree takes on a reddish tone and loses its needles, sometimes resulting in death. Each species constructs a characteristic gallery. From the outside, ***Dendroctonus*** sp. attack can be recognized by the presence of resin globules at the gallery entrance and a large amount of sawdust, especially at the base of the tree. Furthermore, they spread the fungus ***Ceratocystis***, which causes "blue stain" disease in the wood, reducing its commercial value.

Some species, such as ***D. adjunctus***, produce only one generation a year, but ***D. frontalis*** has a life cycle of 26-54 days and can produce up to nine generations a year. Because of this, they can easily reach epidemic densities and produce massive destruction (sometimes of millions of hectares) in natural pine stands, in a short period of time. These epidemics generally last 2-3 years. The durations of each life cycle stage are: 3-11 days for the egg, 15-40 days for the four larval instars, 5-17 days for the pupa and 6-14 days for the soft-bodied, recently emerged adult. The adult measures 2-4 mm in length and is dark brown or black with a well defined groove in the midline of the head.

The female arrives at the tree first to colonize it. She subsequently releases a pheromone or sexual attractant to "call" the male. Copulation occurs in the nuptial chamber which has been bored under the bark. Few individuals undertake the initial attack but substances are released during copulation and boring which attract large numbers of insects, producing a massive attack. Because of the nature of the attack, the tree is unable to protect itself by secreting resin. When the ***D. frontalis*** population is low (endemic phase) the beetles only attack weak trees. When it is high (epidemic phase) they also attack healthy trees to such an extent that even the most vigorous individuals become susceptible.

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After copulation the female constructs a gallery to lay the eggs. In this species it is "S" shaped or serpentine, between 10 and 24 cm long and unbranched. In intense attacks, the galleries can overlap, causing confusion. They are generally constructed in the phloem zone and only rarely affect the edge of the xylem. The female makes small notches or "niches" in the gallery walls and lays one egg in each, laying up to 30 eggs. In 1-3 days the female and male abandon the tree to colonize others. Each female can copulate at least six times.

Each larva makes an individual tunnel in the phloem zone, perpendicular to the main gallery. Pupation occurs in the outer bark. When it has completed its life cycle, the adult bores through the bark to emerge, leaving a well defined, circular hole.

In Mexico and the USA, ***D. frontalis*** attacks several species of pines and other conifers. In Central America it has been reported attacking firstly ***Pinus oocarpa*** and also ***P. pseudostrobus***. In these trees, the trunk may be attacked along the entire length.

As natural enemies, there are many species of mites and predatory insects (from various families of Coleoptera, Hymenoptera and Diptera) as well as parasitoids belonging to eight families.

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Dendroctonus spp.

Adult

Galleries

Globules of resin

References: ISLAS, undated; RODRIGUEZ, 1982; THATCHER *et al.*,undated; WOOD, 1982.

Ips spp.

In Central America, ***Ips interstitialis***, ***I. cribicollis*** and ***I. lecontei*** have been reported as pests specific to pines.

These species are considered secondary pests since they rarely colonize and kill vigorous trees. They are generally associated with bark beetles of the genus ***Dendroctonus***, which predispose the tree to attack. However, under certain circumstances (residual trees, fellings by storms, etc.) population levels can increase explosively and healthy trees can be affected. Generally speaking, each species attacks a specific area of the tree, although all attack the phloem.

Damage is similar to that caused by ***Dendroctonus*** spp., including ***Ceratocystis*** transmission.

These insects are known locally as "engraver" beetles since they affect large parts of the surface of the xylem, leaving "engravings" as they construct their galleries. These galleries have a distinct appearance characteristic of each species. The polygamous male colonizes the tree, excavates the nuptial chamber and bores rudimentary galleries. The male releases pheromones which attract 3-5 females. After copulation, the females finish constructing the galleries and deposit their eggs in niches in the walls. Each gallery can measure up to 30 cm and often has a "Y" or "H" shape with the nuptial chamber in the centre. It is very possible that the adults leave the tree after oviposition.

The larvae make tunnels perpendicular to the main gallery within the underside of the bark. After two or three moults they pupate. The adult makes a circular hole to emerge. There are probably up to twelve generations a year, since in some species the life cycle is only 20-30 days.

The adults are dark brown or black, measuring between 2 and 7 mm. The posterior end is concave and irregular with spines along the edges.

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Ips spp.

Adult

Galleries

References: ISLAS,undated; RODRIGUEZ, 1982; WOOD, 1982.

Scolytodes alni

This species has been observed causing damage to ***Alnus acuminata*** in Costa Rica, especially during the dry season.

The adults are dark brown and measure 2.4-2.9 mm in length. They attack living trees that have been weakened by environmental factors. From the exterior, damage can be recognized by the presence of 1 mm diameter holes in the bark, along with little piles of reddish sawdust. In high infestations there may be one hole per 5 cm^2. The holes lead to galleries located in the phloem. These are longitudinal with many side branches and interconnecting. The galleries may cover the entire perimeter of the trunk causing wilting, defoliation and eventual death of the tree.

All stages of development may be found within the galleries. The larval stage lasts 32 days and the pupa 6 days. The adult lives for 9 days, so that the life cycle is completed in less than two months.

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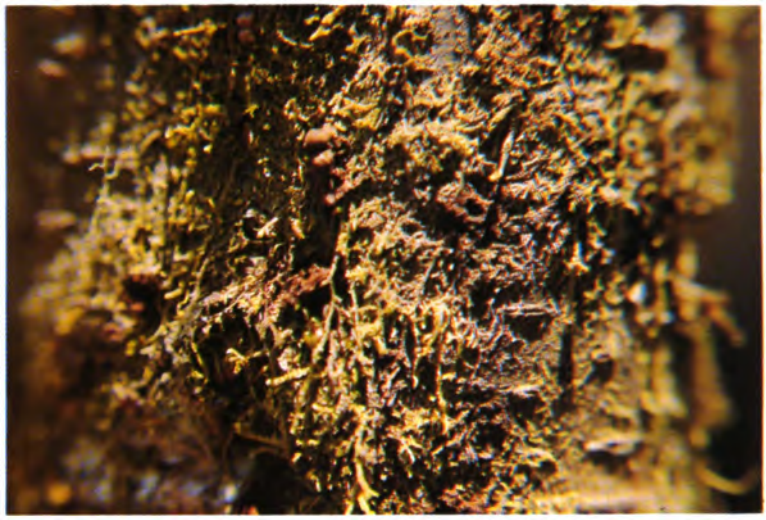
Scolytodes alni



Sawdust piles

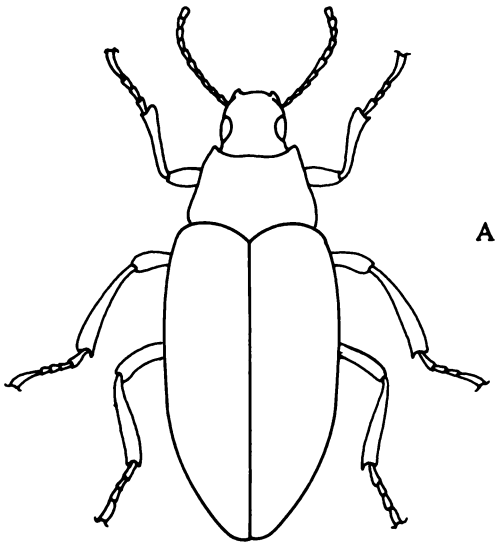
Galleries

References: ARGUEDAS & SCORZA, 1988.

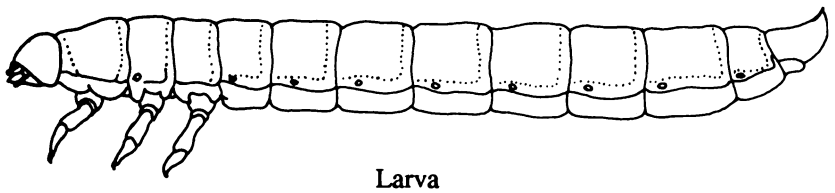
FAMILY TENEBRIONIDAE

This family is made up of a very morphologically heterogeneous group of insects. In general terms, they can be described as follows: small or medium sized adults, brown or black with "C" shaped eyes. The pronotum is wider than the head. The larvae are long and more or less cylindrical, measuring 0.5-4.0 cm with a "Y" or "U" shaped mark or suture on the head. Although the feeding habits of the adults and larvae are very variable, those species of forest importance usually feed on roots or foliage and cut seedlings.

In Panama, adult ***Epitragus*** sp. are important defoliators of ***Guazuma ulmifolia.***



Adult

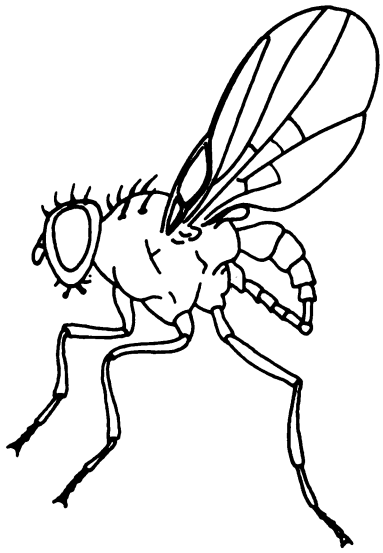


Larva

ORDER DIPTERA

FAMILY AGROMYZIDAE

These are small flies, rarely more than 3 mm in length, blackish or yellowish. The larvae construct mines which are galleries made in the internal leaf tissue (parenchyma). Externally, the damaged areas look transparent and are often twisted and serpentine in appearance.



Adult

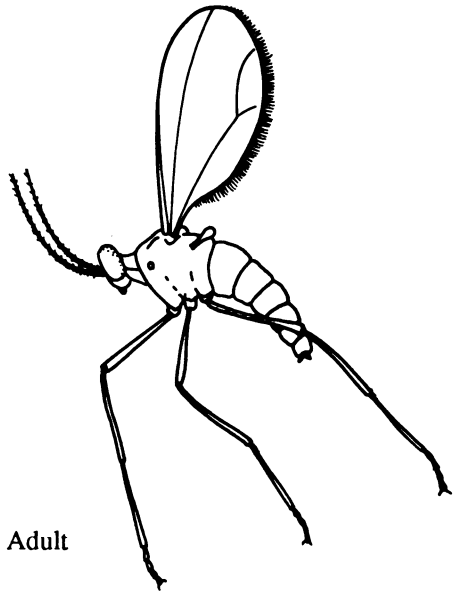
FAMILY CECIDOMYIIDAE

These are tiny flies, rarely more than 2 mm in length. The body is very fragile and easily recognized. The legs are long and thin and the thorax, abdomen, antennae and wings are covered in hairs. The wings have little venation.

Although some species live in decomposing tissue or fungi and others are predators, the majority in this family form galls. These may appear in any part of the plant and the larvae are found inside them. The larvae are nearly always brightly colored: red, orange, pink or yellow and in some species are paedogenetic (reproduction occurs in the larval stage instead of the adult).

In Costa Rica, ***Clinodiplosis*** sp. develops in the leaves of ***Cordia alliodora*** and ***Asphondylia enterolobii*** attacks flowers of ***Enterolobium cyclocarpum***. In Honduras, several unidentified species feed on the cones of three species of pine.

In some Caribbean countries, ***Retinodiplosis forsii*** develops in the base of the needles in new shoots of ***Pinus caribaea, P. occidentalis*** and ***P. cubensis***. In India, ***Asphondylia tectonae*** produces galls in ***Tectona grandis***.



Adult

References: CARLIN & NUÑEZ, 1985; FORD, 1981; JANZEN, 1983 a.

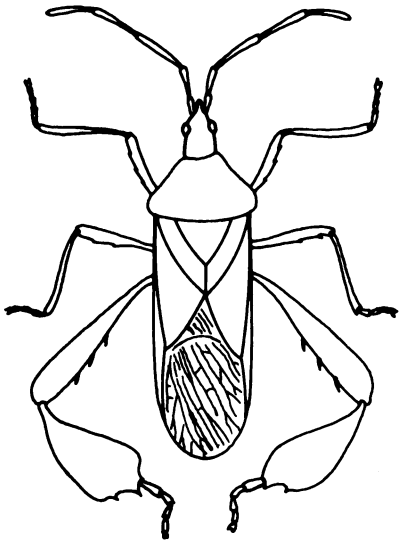
ORDER HEMIPTERA

FAMILY COREIDAE

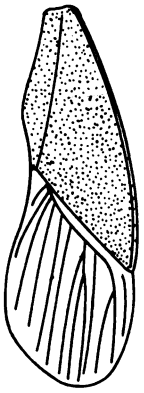
These are quite large bugs, measuring up to 4 cm in length. They are darkly colored and the head is narrower and shorter than the pronotum. In some species the tibia of the hind legs are enlarged, sometimes leaf shaped. Practically all coreids feed on plant sap, although some are predators of other insects.

In Costa Rica, ***Hypselonotus atratus*** attacks ***Cupressus lusitanica*** and ***Alnus acuminata***, and ***Mozena*** sp. attacks ***Bombacopsis quinatum***. In Honduras, ***Leptoglossus*** sp. affects the cones of several pine species.

In the Salomon Isles, an unidentified species causes bud wilting in ***Eucalyptus deglupta***.



Adult

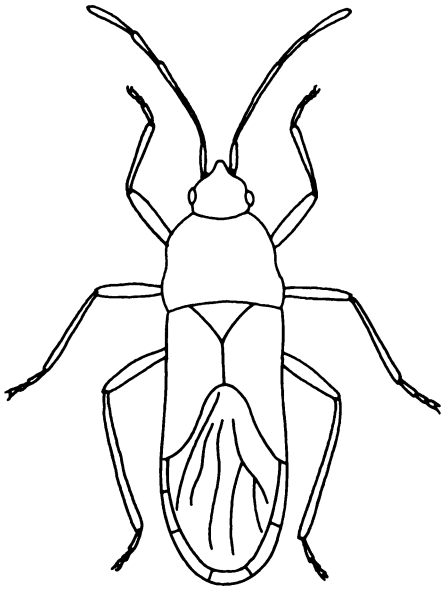


Wing

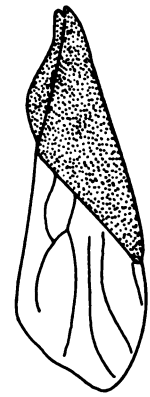
References: CARLIN & NUÑEZ, 1985.

FAMILY LYGAEIDAE

Although some members feed on plant sap or are insect predators, nearly all feed on the liquid inside seeds. The antennae and rostrum have four segments and they nearly always possess ocelli. The wing membrane has only four or five simple veins. They are small bugs with a maximum length around 13 mm and the body shape is variable. Many species have spots or bands in bright colors such as red, black and white.



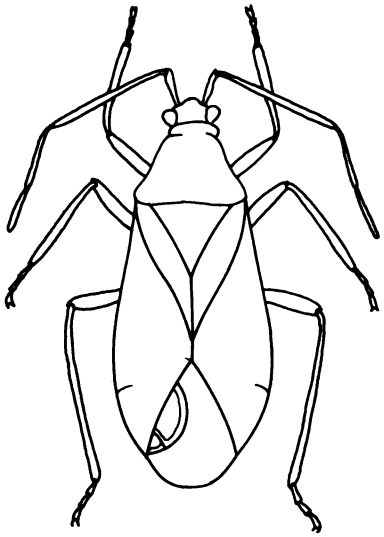
Adult



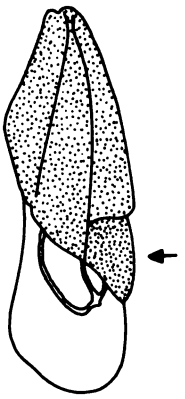
Wing

FAMILY MIRIDAE

Nearly all of these feed on plant sap, although a very few are predators of other insects. They can be distinguished from other bugs by the presence of a cuneus (arrowed in the figure) and nearly all have two closed cells at the base of the wing membrane. They lack oceli and both the antennae and rostrum have four segments. They are small (rarely more than 1 cm), elongated, with a soft body and variably colored



Adult

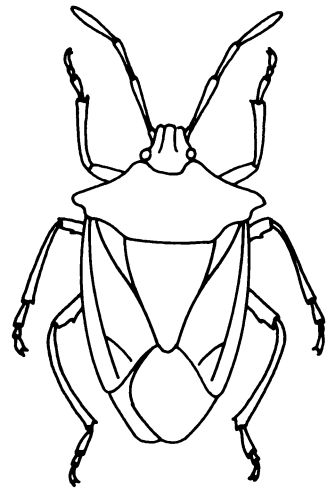


Wing

FAMILY PENTATOMIDAE

These insects are robust with a characteristic shield shaped body. They release an unpleasant odor when they are disturbed. The antennae have five segments and nearly all species are brightly colored. The eggs are barrel shaped and laid in groups. Some species are sap feeders, others predators of other insects and some combine both habits.

In Honduras, ***Tetyra*** sp. sucks the juice from the cones of several species of pines.



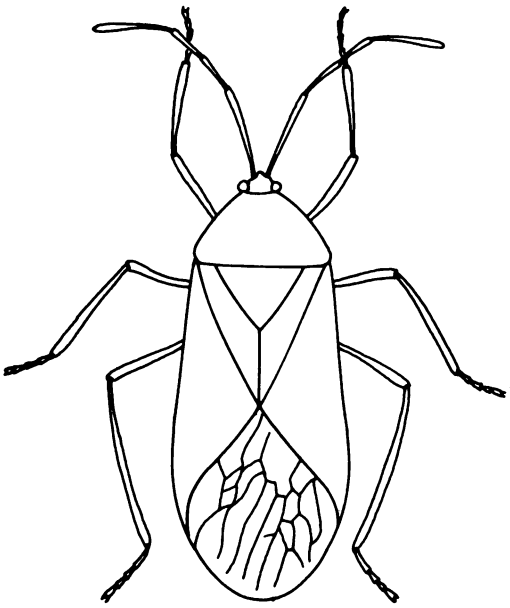
Adult

References: CARLIN & NUÑEZ, 1985.

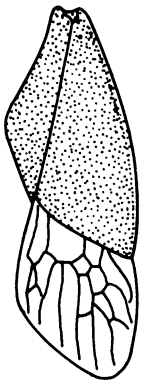
FAMILY PYRRHOCORIDAE

These are medium sized bugs, 15-20 mm in length, elongated oval in shape. They resemble lygaeids, but lack oceli and the wing membrane has branching veins and more cells. Nearly all suck seeds.

In Caribbean countries, nymphs and adults of ***Dysdercus ocreatus***, ***D. sanguineus*** and ***D. andreae*** have been seen sucking on the seeds of ***Hibiscus*** sp. resulting in deformation and falling.



Adult



Wing

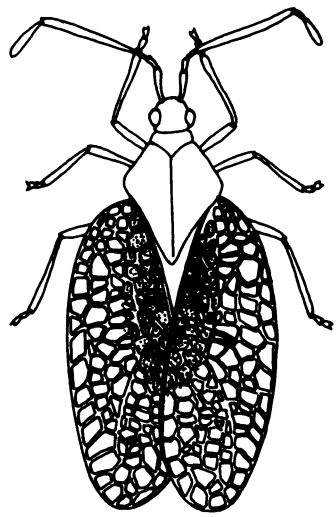
FAMILY TINGIDAE

These insects are known as lace bugs since the dorsal surface of the body appears covered in a fine, membranous, lace-like net. The nymphs are dark colored and are generally spiny. The adults are small, 5-6 mm in length and whitish in color.

These bugs suck the leaves of trees and shrubs, resulting in the appearance of yellow marks. These subsequently turn dark and the leaves fall. They usually lay their eggs on the undersides of the leaves.

In Costa Rica, the most important species is ***Dictyla monotropidia*** which attacks ***Cordia alliodora.***

In India, ***Tingis beesoni*** sucks the sap of ***Gmelina arborea.***



Adult

References: FORD, 1981; NAIR, 1986.

Dictyla monotropidia

The adults are known as lace bugs since their anterior wings look like a fine, semitransparent net. These are longer and wider than the abdomen and light brown ("milk coffee") or sometimes dark brown colored. They measure about 2-2.5 mm. Both adults and nymphs attack ***Cordia alliodora***, especially in nurseries or when less than two years old.

Adults and nymphs in various stages can be found on the underside of the leaf, generally close to the main vein. They suck the sap of the leaves causing wilting, discoloration, death and leaf fall. As the leaf deteriorates, they move to another. In very small plants the damage can cause direct or indirect death, if the sapling succumbs before the weeds, which grow more quickly. In larger trees, the effect is to limit their growth. Damage is seen during the dry season or short dry periods.

The geographic distribution includes many countries from Mexico to Argentina, including Caribbean islands. This species also attacks ***Cordia gerascanthus***, ***C. tomentosa*** and cotton.

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Dictyla monotropidia

Damage

Grouping

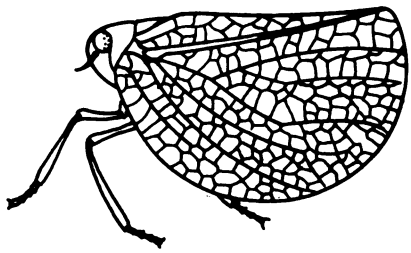
References: FORD, 1981; HOCHMUT & MANSO, 1982.

ORDER HOMOPTERA

FAMILY ACANALONIIDAE

When viewed at rest dorsally, these insects appear laterally compressed. When viewed from the side, the greatly enlarged, slightly rounded anterior wings can be seen. These lack small veins at the edges, which distinguishes them from the Flatidae. The wings are generally green, some with brown patterns. They feed on the sap of trees and shrubs.

In Costa Rica, ***Acanalonia*** sp. has been seen on ***Eucalyptus deglupta.***



Adult

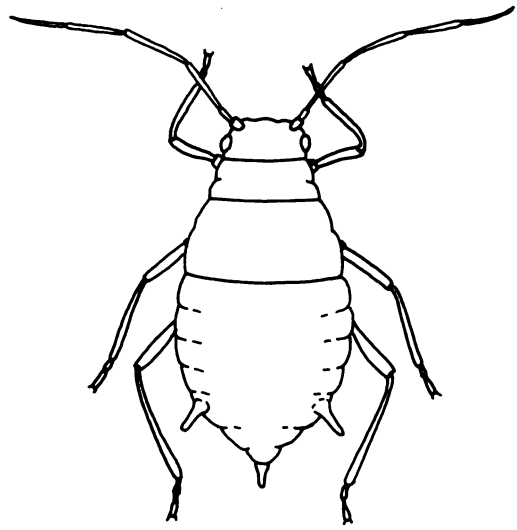
References: FORD, 1981.

FAMILY APHIDIDAE

These aphids or plantlice have soft, pear shaped bodies, long antennae and a pair of cornicles at the posterior end of the abdomen which are used for secreting a defensive fluid. They also secrete honeydew from the anus and this is used as a nutritive medium for a species of fungus. Many species of ants tend aphids and feed on the honeydew. Insects of the family Aphididae suck the sap of leaves and stems and are found on plants in large clusters containing all developmental stages.

The complete life cycle is complex, involving winged and wingless (apterous) forms. In many cases the offspring are parthenogenetic (produced without the need of a male) and viviparous. Some species cause direct damage by sucking sap whilst others transmit viruses which cause diseases.

In Costa Rica, ***Aphis*** sp. has been reported feeding on ***Eucalyptus deglupta*** and ***Cinara*** sp. on ***Pinus caribaea*** and ***P. oocarpa.*** In Guatemala, an unidentified aphid attacks ***Gliricidia sepium.***



Adult

References: FORD, 1981.

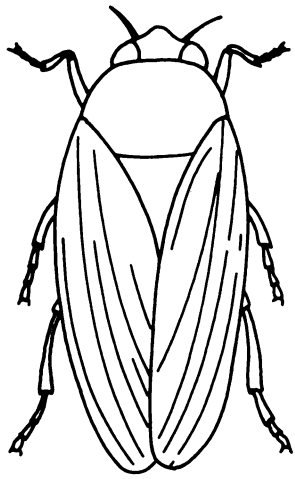
FAMILY CERCOPIDAE

These are often called spittle bugs since the nymphs cover themselves in a large amount of spittle-like froth. This foam is composed of secretions from the anus and epidermal glands in the abdomen, and protects against desiccation and natural enemies. The adults are generally brown or grey, measure under 13 mm long and can jump.

They attack grasses, herbaceous plants, trees and shrubs, sucking sap from flowers, leaves, stems and soft branches.

In Costa Rica, ***Sphenorhina conspicua*** attacks ***Eucalyptus deglupta***, ***Pinus caribaea*** and ***P. oocarpa*** and ***Clastoptera*** sp. attacks ***E. deglupta***. In Guatemala, an unidentified species has been found feeding on ***Gliricidia sepium*** flowers and in Costa Rica, another feeding on branches of ***Calliandra calothyrsus***.

In some Caribbean countries, ***Clastoptera undulata*** attacks ***Casuarina equisetifolia***.



Adult

References: FORD, 1981.

FAMILY CICADELLIDAE

These leafhoppers vary greatly in shape, size (between 2 and 13 mm) and color. The tibiae of the hind legs have one or several rows of small spines. They are found on plants and generally feed on the sap from leaves of grasses, herbs, trees and shrubs where they can cause different types of damage.

Some species suck large amounts of sap and attacked leaves may be covered in tiny white or yellow spots leading to their death. Some species mechanically block the transport of liquids in the leaf so that the outer part turns brown and dries up. Other species lay eggs in twigs producing drying. Others transmit viruses leading to diseases. Yet another group feeds on the underside of the leaf and interferes with its growth; the leaf rolls or twists and stunts the development of the plant. Many leafhopper species produce an anal secretion which falls on the leaf and provides a medium for fungal growth.

In Costa Rica, ***Macunolla ventralis*** feeds on ***Eucalyptus deglupta***, ***Terminalia ivorensis***, ***Cordia alliodora*** and ***Pinus caribaea***. ***Graphocephala coccinea***, ***G. rufinago*** and ***Sibovia occatoria*** appear on ***E. deglupta*** and ***Onchometopia*** sp. has been seen on ***E. deglupta***, ***Leucaena leucocephala*** and ***Terminalia ivorensis***.

In some Caribbean countries, ***Draeculocephala cubana*** and ***Hortensia similis*** have been reported attacking ***Swietenia mahagoni***, ***S. macrophylla*** and ***Cordia gerascanthus*** in nurseries.

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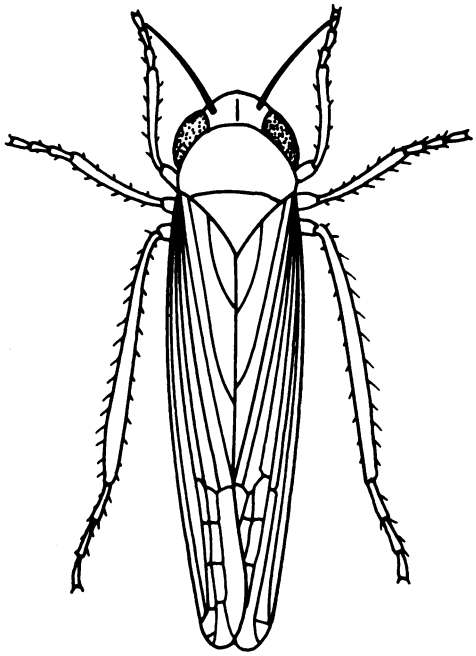
FAMILY CICADELLIDAE



Adult

References: FORD, 1981.

FAMILY CICADIDAE

These insects are known as cicadas and measure between 25 and 50 mm. The males produce loud sounds and sing in chorus. The females generally lay large numbers of eggs on small branches of shrubs and trees and this can cause drying and death of the terminal point. As soon as the egg hatches, the nymph burrows into the soil where it feeds on roots. Some species in temperate climates live 13 to 17 years in the soil as nymphs. When the nymph is mature (ready to turn into an adult) it emerges from the soil and seeks a tree, post or pole to grasp while it moults. The old skin is left adhered to the wood like an empty shell.

In Costa Rica, an unidentified cicada causes drying of twigs in ***Guazuma ulmifolia***, ***Leucaena leucocephala*** and ***Pithecellobium saman***.

Adult

SUPERFAMILY COCCOIDEA

This superfamily includes twelve families of similar morphology and habits which will be dealt with together. Those of most interest are: Coccidae, Pseudococcidae, Diaspididae, Margarodidae and Ortheziidae.

These are all atypical insects known as scale insects or mealybugs, depending on family. The male is almost microscopic and fly-like, with only one pair of wings, the hind wings reduced to halter-like processes usually terminating in a hooked bristle. The extreme posterior of the body has a style-like process. The male lacks mouthparts and does not feed. The females have an oval or globular body with a waxy or scale-like covering. They lack wings, have very small eyes and the legs are reduced or absent. As they are sessile or non-moving, they often look like tiny snails or shells stuck to the plant.

Mealybugs of the family Pseudococcidae can move throughout their lives, but in other families only the first instar nymphs (often called crawlers) can move. These nymphs select a site for moulting on the plant, lose their legs and antennae and secrete a waxy covering. They stay in this site for the rest of their lives, feeding on sap with long filamentous stylets. After copulating (some species are hermaphrodite, others parthenogenetic) large numbers of eggs are laid and guarded under the female's shell until they hatch into crawlers. Some species are viviparous. Females of the family Diaspididae are the only ones whose scale covering is free from the body.

Although there is great morphological variation, the most important families can be characterized in general terms. The mealybugs (Pseudococcidae) have flat bodies covered in different colored powdery wax. They may be oval or elongated with lateral prolongations. The legs are well developed and body segmentation visible. The "ground pearls" (Margarodidae) are robust, brown, with a striated or grooved sac of white eggs attached to the body. The Ortheziidae are elongated and the body is covered with white, waxy plates. They also have white, waxy or striated bags containing pink eggs. The "soft scales" (Coccidae) have white, waxy shells shaped like limpets in a variety of colors. Finally, the "armored scales" (Diaspididae) are small, flat and circular or oyster shaped, with a hard covering.

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SUPERFAMILY COCCOIDEA

Members of this superfamily may attack foliage, buds, stems, twigs, fruits and even roots (some pseudococcids, margarodids and ortheziids) of trees. Sap loss results in desiccation and death of the affected part. This can have serious consequences, especially in forest nurseries. Furthermore, some species transmit viruses. Many secrete a honeydew and are tended by ants that feed on it.

In Costa Rica, ***Saissetia*** sp. (Coccidae) has been seen on the undersides of leaves of ***Eucalyptus deglupta.***

In some Caribbean countries, ***Icerya purchasi*** (Margarodidae) attacks ***Casuarina equisetifolia*** and other broadleafs, while in Nigeria, ***Saissetia farquarsoni*** (Coccidae) feeds on ***Tectona grandis.***

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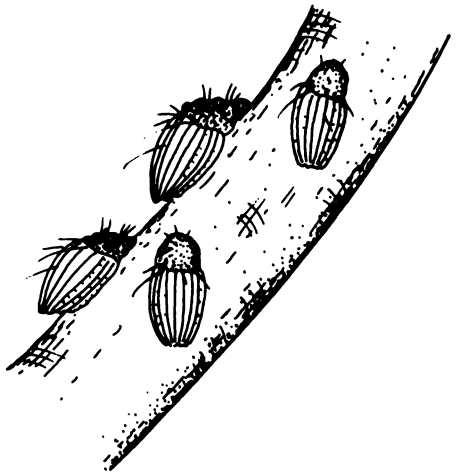
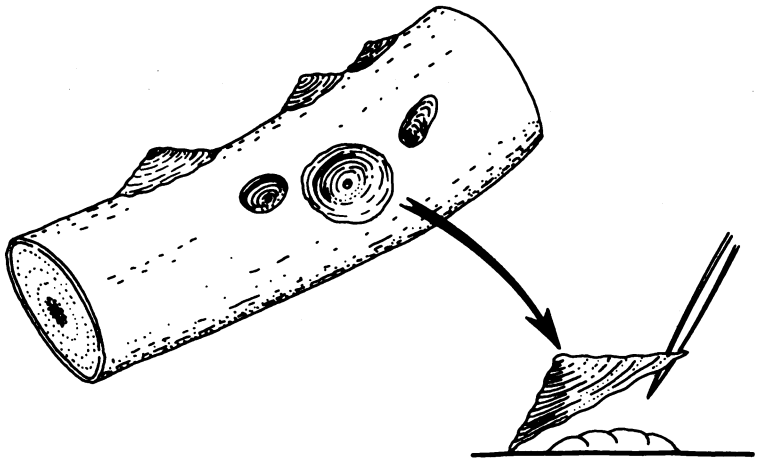
SUPERFAMILY COCCOIDEA



Coccoidea: Ortheziidae



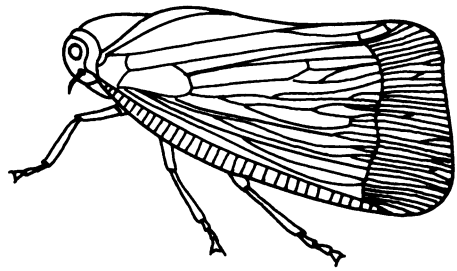
Coccoidea: Diaspididae

References: ANDREWS & CABALLERO, 1989; FORD, 1981; WILLE & FUENTES, 1970.

FAMILY FLATIDAE

Seen at rest from the side, the adults of these insects appear triangular in shape with parallel venation along one edge of the wings. Viewed dorsally, they appear compressed. They are nearly all pale green or dark brown and feed on the sap of trees, shrubs and reeds.

In Costa Rica, ***Hesperopanthia championi*** has been seen feeding on ***Leucaena leucocephala*** and ***Hansenia pulverulenta*** on ***Eucalyptus deglupta, Pinus caribaea*** and ***Terminalia ivorensis.***



Adult

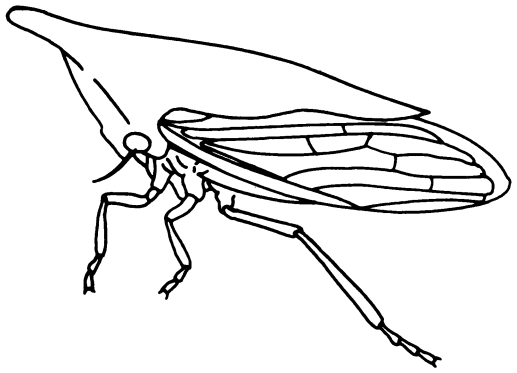
Reference: FORD, 1981.

FAMILY MEMBRACIDAE

These treehoppers can be recognized by the size and shape of the pronotum which is large, covers the head, extends over the abdomen and is sometimes spined, horned or keeled. The wings are generally concealed by the pronotum. They measure between 10-12 mm and feed on trees and shrubs, although the nymphs of some species feed on grasses and herbaceous plants. Some species lay eggs in cracks made in twigs, resulting in desiccation.

In Costa Rica, ***Aconophora ferruginea***, ***Bolbonota inaequalis***, ***Ceresa concinna***, ***Enchenopa lanceolata*** and ***Micrutalis lugubrina*** feed on ***Eucalyptus deglupta*** and ***Umbonia crassicornis*** feeds on several members of Leguminosae.

In India, ***Leptocentris vicaris*** feeds on the inflorescence of ***Tectona grandis***.



Adult

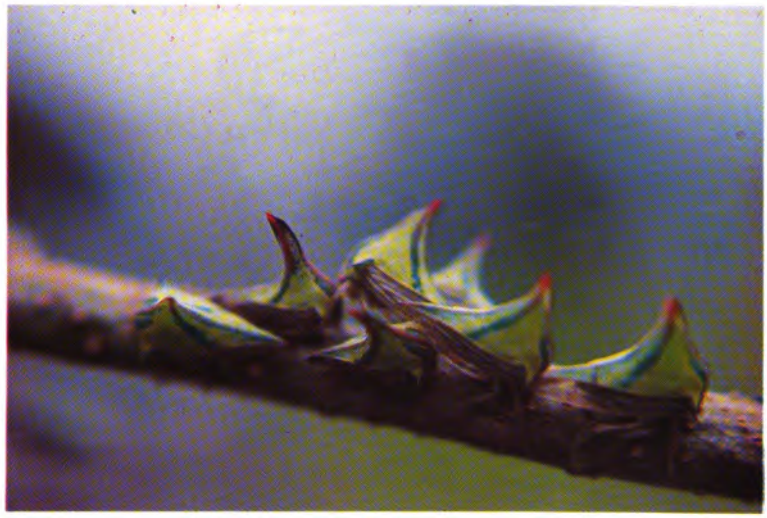
References: FORD, 1981; SEN-SARMA, 1986.

Umbonia crassicornis

These are pale green insects which live in groups on small branches of trees and look like spines. They are often found at the edges of forests and in disturbed areas, on a variety of plants. They seem to prefer leguminous plants such as ***Calliandra*** sp., ***Albizzia lebbek***, ***A. guachapele***, ***Lysiloma bahamensis***, ***Enterolobium cyclocarpum*** and ***Inga*** spp.

The female inserts eggs in the branches and petioles of the host plant and stays to look after the nymphs when they hatch. They are generally found on branches less than 1 cm in diameter where they suck the sap. The leaves become yellow and drop and the branch desiccates.

The species has a wide range of distribution, from southern Florida (U.S.) to Brazil.



Adult

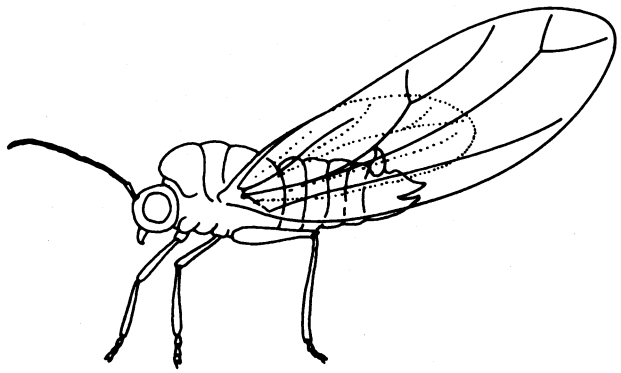
References: JANZEN, 1983a.

FAMILY PSYLLIDAE

These are called "jumping plant lice" and measure only 2-5 mm in length. They slightly resemble aphids but have strong jumping legs and relatively long antennae. Adults of both sexes are winged and have a short, three segmented "beak". The nymphs of many species produce large amounts of a white, waxy material which may cause them to be confused with mealybugs. They are all sap feeders and some transmit viral diseases. A few species produce galls.

In Costa Rica, Honduras, El Salvador and Nicaragua, ***Heteropsylla cubana*** has been reported on ***Leucaena leucocephala.*** In Costa Rica, ***Paracarsidara*** sp. attacks ***Bombacopsis quinatum***, ***Mastigimas*** sp. attacks ***Cedrela odorata***, ***Heteropsylla huasachae*** attacks ***Albizzia guachapele***, and ***Limbopsylla beeryi*** attacks ***Hymenaea courbaril.***

In some Caribbean countries, ***Coelocara ernestii*** affects young plantations of ***Cedrela odorata.*** In Nigeria, ***Diclidophlebia eastopi*** and ***D. harrisoni*** attack ***Triplochiton scleroxylon*** in nurseries. In India, nymphs of ***Trioza obsoleta*** form galls on the foliage of ***Diospyros melanoxylon.***



Adult

References: FORD, 1981; SEN-SARMA, 1986

ORDER HYMENOPTERA

FAMILY APIDAE

This family comprises the bees, including the European bee which is so important for pollinating several plants. From the forestry point of view, the most important are the stingless bees of the genus ***Trigona*** which lack venom. Although these bees are pollinators and hence benefit the tree, they also damage the trees when they remove the resins which they use along with other vegetable matter to construct their nests. These are compact and hard, generally found in the branches of trees, although one species builds them in termite nests. During their daily activities they may travel from 600 to 800 m from the nest.

In Costa Rica, these bees cause different types of damage according to species:

a) ***Trigona corvina*** cuts the terminal buds of ***Eucalyptus deglupta*** and has been seen collecting resin from wounds in the trunks of ***Pinus caribaea.*** It also cuts the flower buds of some citrus trees.

b) ***Trigona cupira*** extracts resin by making incisions in the bark of ***Eucalyptus citriodora, E. grandis, Pinus caribaea, P. elliottii*** and ***P. oocarpa.*** It also defoliates ***Alnus nepalensis.***

c) ***Trigona ferricauda*** causes damage similar to ***Trigona cupira*** in ***Eucalyptus*** spp. and ***Pinus*** spp.

d) ***Trigona fuscipennis*** chews the leaf primordia of ***Acacia mangium*** when it seeks nectar, producing multiple perforations in the leaves. It also causes considerable defoliation in macadamia and cuts floral buds in certain citrus species.

e) ***Trigona silvestriana*** cuts seedlings of ***Pinus caribaea, P. elliottii*** and ***P. oocarpa.*** It also makes incisions in the bark of these species along with ***Casuarina equisetifolia, Cordia alliodora, Eucalyptus citriodora, E. grandis, E. saligna, Khaya ivorensis, Columbrina ferruginosa*** and ***Acacia mangium.*** In the case of ***A. mangium,*** the damage is associated with perforations made by beetles of the Platypodidae and Scolytidae which appear to arrive first. ***T. silvestriana*** also cuts the flower buds of some citrus species.

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In Brazil, ***T. spinipes*** attacks ***Araucaria angustifolia*** and ***T. hyalinata*** attacks ***Pinus*** spp.

Adult

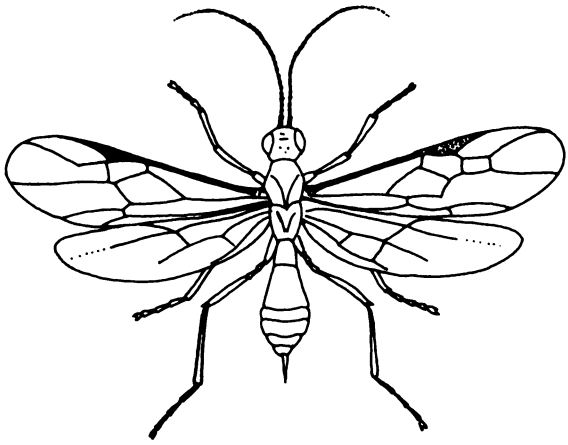
Foliage damage

Damage to trunk

References: FORD, 1981; GARA, 1970; WILLE, 1965.

FAMILY BRACONIDAE

Although nearly all the species of this family are beneficial since they are pest parasitoids, some do damage seeds. The adults are small, rarely measuring more than 15 mm. The wing venation is well developed and there is a clear mark or stigma on the forewing. They may be confused with ichneumons, but the latter are exclusively parasitoid and have three recurrent veins in their wings whereas the braconids have only one or none.

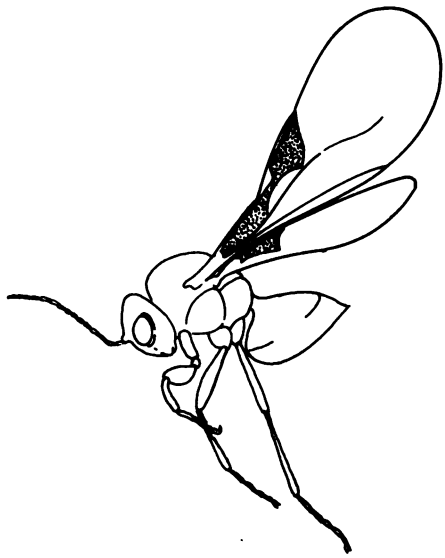


Adult

FAMILY CYNIPIDAE

Many species in this family are parasitoids, but some form galls in plants. These gall-forming cynipids are small, generally shiny black with a laterally compressed abdomen. The type of gall and its location on the plant are both characteristic of each species.

In Costa Rica, many species of this family produce galls on ***Quercus*** spp.



Adult

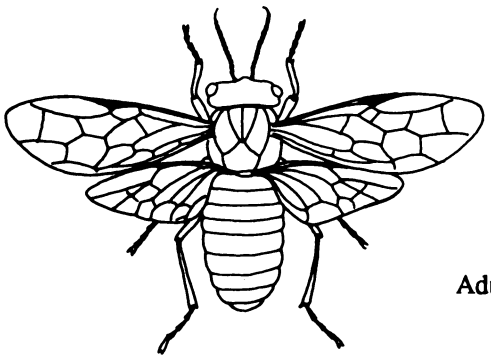
FAMILY DIPRIONIDAE

The adults of this family are medium sized sawflies without a constriction or "waist" dividing the thorax and abdomen. The antennae have 13 or more segments and are serrated in the female and pectinate or bipectinate in the male.

The larvae have eight pairs of prolegs and many rings or false segments on the dorsum. The antennae have three segments; the first two are flat and round whilst the third forms a spike or heel. The body is greenish and the head black or orange. They attack conifers causing massive defoliation. The larvae feed in groups, especially during the first instars. When their development is complete, they spin a cocoon in which they pupate either on the ground or fastened to needles, twigs, branches or the trunk.

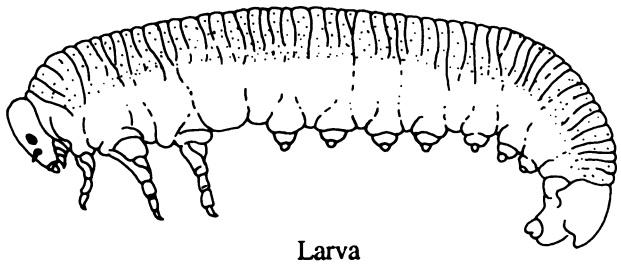
In Guatemala and Honduras there are several species of the genera ***Neodiprion*** and ***Zadiprion***.

In some Caribbean countries, ***Neodiprion insularis*** attacks ***Pinus caribaea*** and ***P. occidentalis***.



Adult

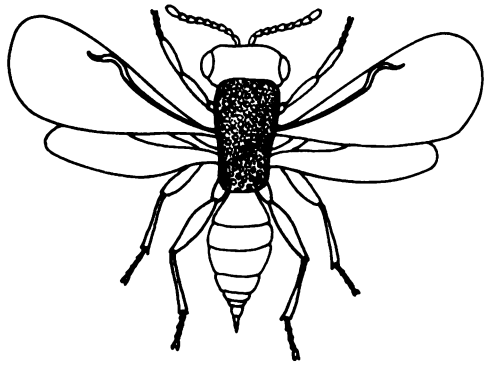
Larval antenna



Larva

FAMILY EURYTOMIDAE

These are extremely small chalcids with varying habits. Some are pest parasitoids, others attack grass stems and others infest the seeds of some plants, especially Leguminosae. The thorax of the adult is rough and coarsely punctate in the superior part, resembling tiny craters.

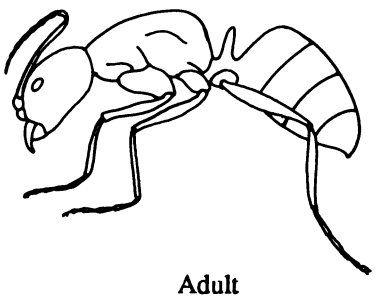


Adult

FAMILY FORMICIDAE

This family includes all the ants. These are social insects and three castes can be distinguished: queens, males and workers. The queens and males have wings which are used for the nuptial flight and colonizing new sites. The workers are sterile females and are wingless. The habits of ants are very variable and, according to species, they may feed on living or dead animals, plants, fungi, sap, nectar, honeydew secretions of other insects and domestic produce. From the forestry point of view, the most important are the leaf cutters and those that chew the bark of trees and stumps and destroy seeds in nurseries.

In Central America, the most common ants are the leaf cutting ants (*Atta* spp.) and ***Acromyrmex octospinosus*** which defoliate many forest species.



Adult

References: FORD, 1981; KING & SAUNDERS, 1984.

Atta spp.

There are three species of leaf cutters in Central America: ***Atta cephalotes***, ***A. sexdens*** and ***A. colombica***. These ants cut leaves into almost circular pieces and transport them to their nests. Here they are shredded and used as a substrate for a fungus which constitutes the colony's main food. The nests are underground with extensive tunnels provided with air shafts. Above ground, piles of earth can be seen at the exit holes. At the beginning of the rainy season, many winged individuals in the reproductive stage appear for the nuptial flight. After mating, the females or queens start new colonies.

The ants normally attack a tree only once, causing severe defoliation. They are polyphagous and attack many forest species including ***Cupressus lusitanica***, ***Eucalyptus*** spp., ***Pinus*** spp., ***Leucaena leucocephala***, ***Bombacopsis quinatum***, ***Gmelina arborea***, ***Tectona grandis*** and ***Acacia mangium***.

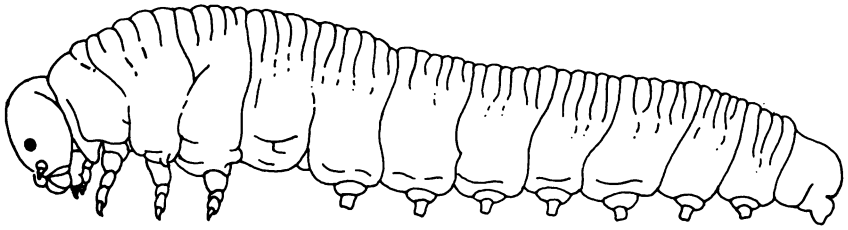
Adult

References: BROWNE, 1968; KING & SAUNDERS, 1984.

FAMILY TENTHREDINIDAE

These are medium sized sawflies, rarely longer than 2 cm and without the constriction or "waist" separating the thorax and abdomen. They are brilliantly colored and have 7-10 segmented, filiform antennae. The larvae resemble those of the Diprionidae but with five segmented, conical antennae. Most are defoliators, feeding from the edge of the leaf until only a skeleton is left, but some species are miners, others form galls in different parts of the plant and others are bud borers.

Adult



Larva

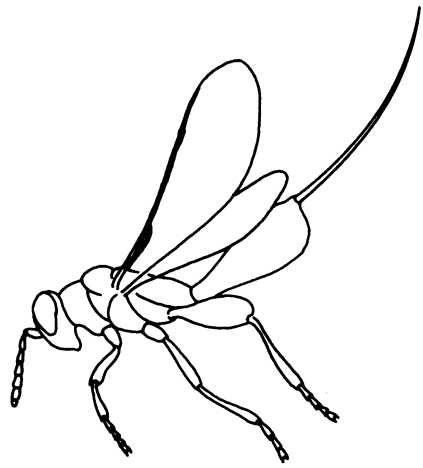
Larval antenna

FAMILY TORYMIDAE

These are tiny insects, 2-4 mm in length, slightly elongated, metallic green or bronze in color. The coxae of the hind legs are very long and the females have a long, curved ovipositor.

Some of these insects are parasitoids, especially of other gall forming insects, whilst others attack seeds. The genus ***Megastigmus*** has several species which attack conifer seeds especially in North America and Central American countries such as Honduras and Guatemala.

In Caribbean countries, ***Bootamomyia*** sp. attacks and destroys seeds of ***Casuarina equisetifolia.***



Adult

References: CARLIN & NUÑEZ, 1985; CIBRIAN *et al.*, 1986.

Megastigmus spp.

These are tiny insects, 3.4-5.7 mm in length, characterized by a large, dark pear or mallet shaped stigma on the anterior margin of the fore wing. The females, which are larger than the males, have a strong, curved ovipositor, almost as long as the body. They are generally yellowish green, brown or black. They attack several species of pine, such as ***P. caribaea***, ***P. oocarpa***, ***P. maximinoi*** and conifers of the genera ***Abies***, ***Picea*** and ***Pseudotsuga***. With its large ovipositor, the female perforates the kernels of young cones and inserts eggs in the forming seeds. More than one egg may be laid in each seed but only one larva develops. This feeds on the seed contents and pupates there. The adult has to make a gallery to exit from the cone. The gallery is circular, approximately 1 mm in diameter and free of residue. Until the emergence hole appears, it is impossible to tell whether the seed has been attacked or not, except by X-ray. The larva leaves no evidence of its presence either on the cone or seed. The insects within the seeds avoid detection, in spite of quarantine measures, and this facilitates the spread of the pest. The life cycle lasts approximately one year. In some species, parthenogenesis has been recorded.

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Megastigmus spp.

Adult

Damage

References: CARLIN & NUÑEZ, 1985; CIBRIAN *et al.*, 1986; COULSON & WITTER, 1984; RODRIGUEZ, 1982.

ORDER ISOPTERA

FAMILY KALOTERMITIDAE

This family includes the termites, which have a flat, slightly rectangular pronotum, slightly wider than the head. They have ocelli but lack a fontanelle (a small depression where the frontal gland opens). These insects live in colonies in galleries constructed in wood rather than in nests. The colonies are relatively small with only a few hundred individuals. They are divided into soldiers (with large heads and powerful mandibles) and reproductive forms. The work is done by immature reproductive forms. Colony members never go outside the galleries except for the reproductive flight and for dispersal. For this reason the damage to the wood is not visible from outside.

Some species attack damp wood and tree roots, others dry wood (in buildings, furniture, posts and lumber) and others pulverize construction wood or feed on books and paper.

In Central America, the most common species is ***Cryptotermes brevis***, which prefers dry wood.

In some Caribbean countries, ***Neotermes castaneus*** attacks the trunks of living ***Tectona grandis***, ***Cedrela odorata*** and ***Bursera simaruba*** and ***Kalotermes approximatus*** attacks ***Juniperus bermudiana***. In Java, ***Neotermes tectonae*** attacks ***Tectona grandis***.

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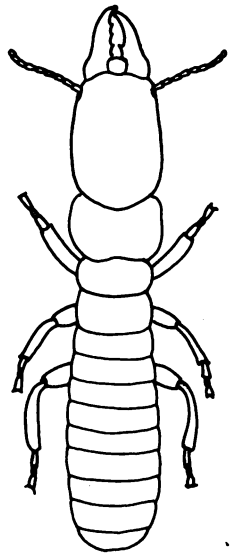
FAMILY KALOTERMITIDAE



Adult

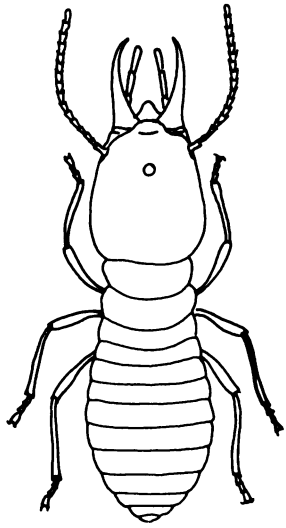
References: WILLE & FUENTES, 1970.

FAMILY RHINOTERMITIDAE

These termites are characterized by a flattened pronotum with a fontanelle. They are normally subterranean. They construct tunnels or tubes of vegetable matter and earth from their underground nests leading to wood not in contact with the soil. Where the wood is in contact with the soil, it is attacked directly.

In Central America, the most common species is ***Coptotermes testaceus***. In Costa Rica, ***C. crassus*** has been reported to destroy the heartwood of ***Cupressus lusitanica***, ***Eucalyptus deglupta*** and ***Araucaria hunsteinii*** at the base. All these were entered from the soil, without appreciable external damage. Attacks are generally made on trees weakened by pathogens or abiotic factors. ***C. niger*** attacks ***Pinus*** spp. and ***Swietenia mahagoni***.

In New Guinea, ***Coptotermes elisae*** attacks healthy trees of ***Araucaria cunninghamii***. In Colombia, ***C. niger*** attacks ***Goupia glabra***, ***Humiriastrum coloumbiarium*** and ***Xylopia*** sp. in natural forests. ***Heterotermes indicola*** and ***C. brevis*** attack dry wood and forest products in India and Puerto Rico, respectively.



Adult

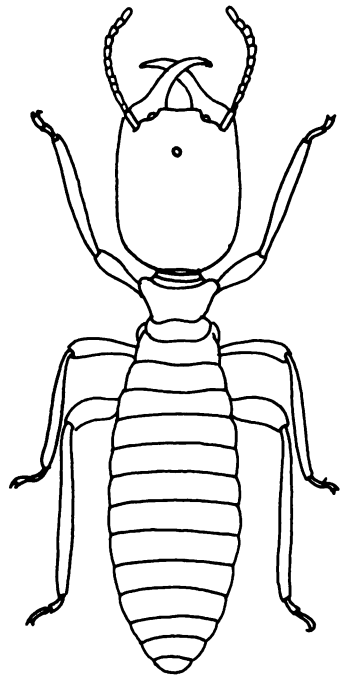
References: FORD, 1981; WILLE & FUENTES, 1970.

FAMILY TERMITIDAE

These termites have a narrow pronotum, lobed in the mid part and with a fontanelle. The social structure is complicated: some species build aerial nests between the branches of trees.

In Costa Rica, ***Nasutitermes corniger*** is often seen in plantations of ***Gmelina arborea***, although it only attacks dead branches.

In other tropical countries of Africa and Asia, ***Odontotermes parvidens*** has been seen attacking ***Tectona grandis*** and two species of ***Macrotermes*** damage ***Eucalyptus*** spp. seedlings.



Adult

References: FORD, 1981.

Nasutitermes corniger

This termite species has been seen in ***Gmelina arborea*** plantations, ***Acrocarpus fraxinifolius*** and several other trees.

They do not seem to cause damage, only feeding on dead branches. Their presence is evidenced by the tunnels or sawdust tubes adhering to the surface of the trunk. The termites use these to travel from nest or soil to the axillae of the dead branches. They sometimes build nests in the soil or, more often, on the branches. The nests are strong, spherical and made of cemented wood particles, with the consistency of cardboard. Some authors believe that these nests, which can be up to 50 cm in diameter, can limit the growth of the tree.

Three types of individual can be recognized in the colony: winged adults, workers and soldiers. Some soldiers (nasuti) exhibit an elongation of the anterior of the head forming a narrow beak or proboscis.

Tunnel

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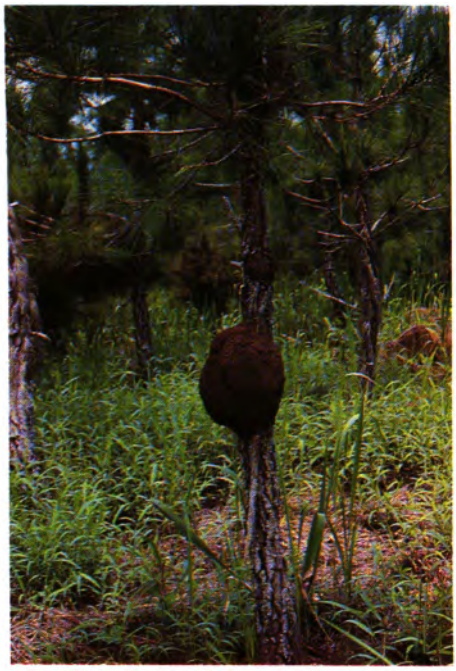
Nasutitermes corniger



Nest

Colony

References: FORD, 1981.

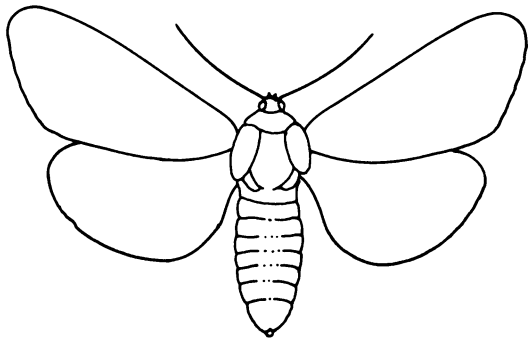
ORDER LEPIDOPTERA

FAMILY ARCTIIDAE

The adults are small or medium sized moths with a wingspread up to 6 cm. They usually have brightly colored bands or markings. Mature larvae may measure 1-8 cm, are robust and hairy and fairly inactive although they are capable of rapid movement. They feed on the foliage of herbaceous plants, trees and shrubs.

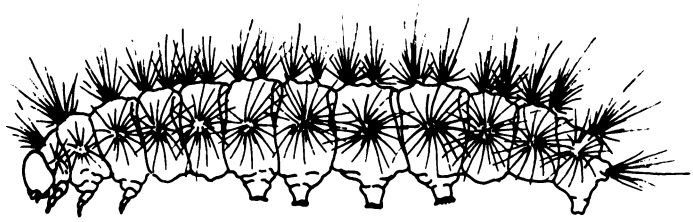
In Costa Rica, ***Melese*** sp. has been observed feeding on ***Hibiscus elatus*** and two unidentified species were seen defoliating ***Alnus acuminata*** and seedlings of ***Quercus costaricensis***. In Honduras, two unidentified species attack ***Leucaena leucocephala*** and two others ***Gliricidia sepium***.

In Brazil, ***Eupseudosoma involuta*** defoliates several species of ***Eucalyptus***.



Adult

Larva



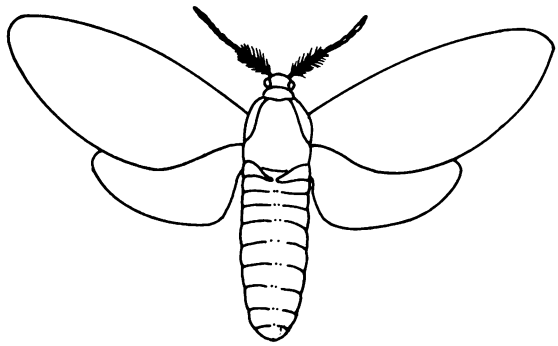
References: GALLO *et al.*, 1978; GARA, 1970.

FAMILY COSSIDAE

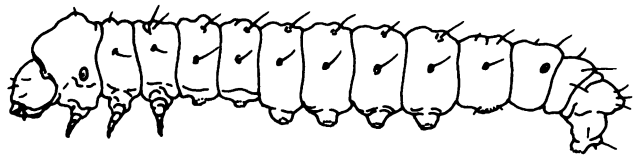
The adults are relatively large and heavy bodied with a wingspread of about 5-7 cm. The wings are spotted or mottled, tend to be narrow and are opaquely colored. The larvae generally feed on woody tissue, boring into trunks and branches of trees, but some feed on roots or herbaceous plants and even cactus. The females lay eggs in cracks in the bark, in wounds or in lichen on the bark. After hatching, the larvae bore into the tissue and pupate inside the tree. The pupa moves to the emergence hole before becoming an adult and leaving the tree.

In Costa Rica, ***Cossula*** sp. bores into three species of ***Terminalia*** and one unidentified species attacks ***Mimosa scabrella.***

In Asia and the Pacific, ***Cossus cadambae*** and ***Xyleutes ceramica*** bore into ***Tectona grandis.*** The latter also attacks ***Vitex parviflora*** and ***Zeuzera coffeae*** bores into ***Eucalyptus deglupta.***



Adult



Larva

References: FORD, 1981.

Cossula sp.

The larva of this species is cylindrical and robust with a distinct hump on the prothorax. It is deep pink in color with a blue back. When mature, it may measure up to 7 cm long and 0.9 cm in diameter.

The first larval instars feed on the phloem and from there start to bore into the xylem. Here, a hole can be seen leading to a vertical gallery in the pith. The gallery may measure 25-40 cm long and 9-11 mm in diameter. In trees with broad trunks, the larva may not reach the pith, but builds a vertical gallery in the xylem.

The insect attacks ***Terminalia oblongata*** or ***T. lucida, T. amazonia*** and ***T. ivorensis*** trees with a diameter greater than 6-8 cm. Damage may occur from soil height to 15 m high. From the outside of the trunk, a hole with frass can be seen along with exudating sap or resin which stains a large area of the bark. There are generally only one or two holes per tree, but they may serve as entry holes for diseases. Most damage occurs at the beginning of the rainy season.

The mature larva pupates at the top of the vertical gallery. When it is ready to become an adult, it moves to the mouth of the tunnel leaving part of its body exposed. The adult is a heavy bodied moth covered in grey-brown scales and with a wingspread 4-5 cm.

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Cossula sp.

Damage

Larva

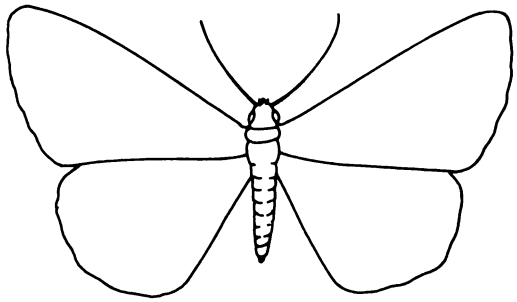
Adult

References: FORD, 1986b.

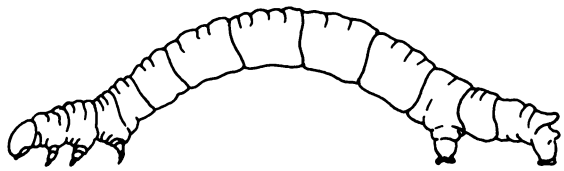
FAMILY GEOMETRIDAE

The larvae of this family are known as "loopers" or "inchworms" because of their way of moving. This is because they only have two or three pairs of posterior prolegs and none in the middle. Progression is made by placing the posterior end close to the thoracic and then moving the anterior forwards in the characteristic looping fashion. They generally feed on leaves. The adults are small, thin and delicate. They have a 4 cm wingspread, the wings being wide and marked with fine wavy lines.

In some tropical Latin American countries, ***Cupressus lusitanica*** and ***Pinus*** spp. are defoliated by ***Glena bisulca***, ***Eucalyptus citriodora*** and ***E. paniculata*** by ***Thyrinteina arnobia***; ***Eucalyptus*** spp. by ***Sabulodes caberata*** and ***Guaiacum*** sp. by ***Iridopsis*** sp. and ***Semiothisa*** sp.. In Asia, ***Pinus merkusii*** is defoliated by ***Milionia basalis*** and ***P. kesiya*** by ***M. coronifera.***



Adult

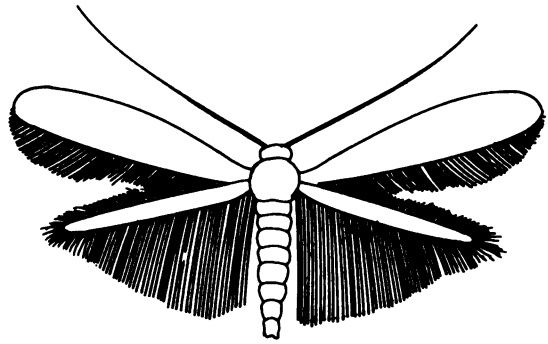


Larva

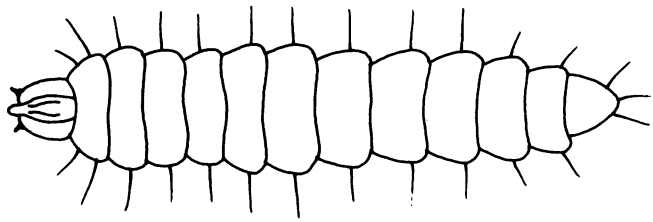
FAMILY GRACILARIIDAE

Adults of this family are usually tiny moths with lanceolate wings. When at rest, the moth raises the anterior part of its body whilst the wing tips touch the surface on which it is resting. The larva mines the leaves of some plants, forming transparent, sometimes twisting, serpentine areas and making the leaf wrinkle. The larva pupates in a small silk cocoon located at the far end of the mine.

In Costa Rica, ***Phyllocnistis meliacella*** mines the leaves of five species of Meliaceae.



Adult



Larva

References: BECKER, 1976.

Pyllocnistis meliacella

The larva is a leaf miner of several species of Meliaceae, such as ***Cedrela odorata***, ***C. angustifolia***, ***C. tonduzii***, ***Swietenia macrophylla*** and ***S. mahagoni***.

Attacks can be seen in young leaves just twenty days old. The larva lives beneath the epidermis of the underside, feeding on the sap. There is generally only one larva per leaf, but occasionally two may be found. The larva builds an irregular, twisting gallery or mine, which grows in size along with the larva. The mine extends over the whole leaf, through the veins and ends at the leaf border where the larva builds a pupal chamber. This is made by folding under the edge of the leaf and securing it with cream colored silk threads.

The larva is long, dorsoventrally flattened, lacks legs and hair and has two long, pale greenish colored caudal appendages. When fully developed, the larva measures about 5 mm. The pupa is cream colored and measures 3mm. The adult is silvery white with a wingspread of 4-4.4 mm and proportionately long antennae (2 mm). The life cycle is completed in about one month.

A large percentage of the larvae have been found parasitized by the hymenopteran ***Horismenus*** sp. (Eulophidae)

Damage

References: BECKER, 1976.

FAMILY HEPIALIDAE

The adults are medium or large sized moths with a wingspread up to 15 cm and short antennae. The wings are opaque brown or grey with silvery markings. They are rapid fliers. The females produce thousands of eggs (2,500-29,000 depending on species) and release them during flight.

The mature larva measures from 2.8-7.5 cm. It feeds on roots or woody tissue which it reaches by boring tunnels. Larvae normally bore into the pith of trees and shrubs, but some may ring the bark. A bag of silk, excrement and wood chips made by the larva may often be seen on the bark.

In Costa Rica, ***Aepytus*** sp. has been found boring into ***Gmelina arborea***, ***Bombacopsis quinatum***, ***Guazuma ulmifolia*** and ***Tabebuia rosea***. ***Phassus triangularis*** has been found on ***Fraxinus uhdei*** and other unidentified species on ***Alnus acuminata*** and ***Gmelina arborea***. Hepialid larvae are frequently seen on different families of wild plants.

In some Old World tropical countries, ***Sahyadrassus malabaricus*** bores into ***Tectona grandis*** and ***Eucalyptus*** sp.; ***Endoclita sericeus*** attacks ***Tectona grandis***, ***Albizzia*** sp. and ***Caesalpinia*** sp.; ***Phassus signifer*** attacks several species of ***Pinus*** and ***Albizzia julibrissin*** and ***Aenetus astathes***, ***A. eximius***, ***A. lewinii***, ***A. ligniveren*** and ***A. paradiseus*** attack species of ***Eucalyptus***, ***Acacia*** and ***Casuarina***.

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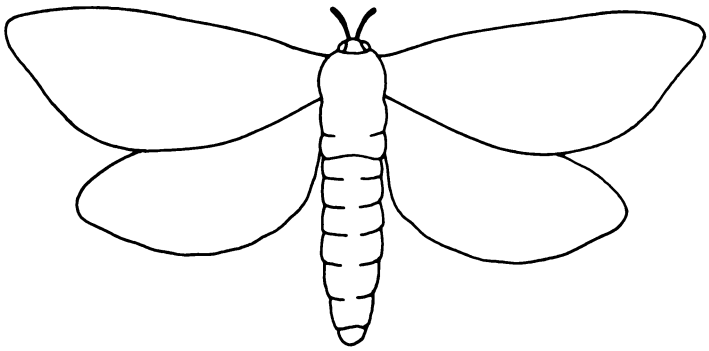
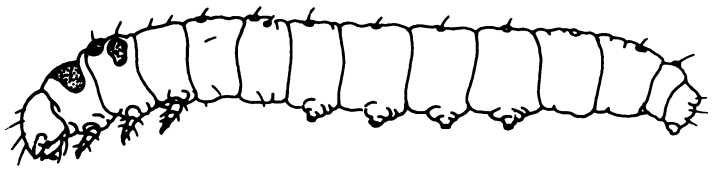
FAMILY HEPIALIDAE



Adult



Larva

References: FORD, 1981; MORENO, 1989.

Aepytus sp.

The mature larva can measure up to 5.5 cm long. It is cream colored, has a dark, rounded head and a reddish plate on the upper part of the prothorax. Its presence in ***Gmelina arborea***, ***Bombacopsis quinatum***, ***Guazuma ulmifolia*** and ***Tabebuia rosea*** can be detected by the bag which adheres to the trunk and sometimes the axils of branches. When this bag is raised, a small hole can be seen. This is the opening of the tunnel which extends to the pith where it moves vertically. The vertical part of the tunnel may be up to 15 cm long and point upwards or downwards apparently depending on the thickness of the affected trunk. The bags appear at the base of the tree and up to 3 m in height. They are most common below 50 cm and up to four may appear on the same tree.

It is assumed that, like other hepialid larvae, the first larval instars of ***Aepytus*** sp. feed on fungi found on decomposing organic matter, perhaps associated with weeds. The female disperses the eggs (possibly more than 2,000 per female) on weeds. The larva has been found boring into several species of herbaceous plants and shrubs of the families Verbenaceae, Rubiaceae, Compositae, Melastomataceae, Euphorbiaceae, Ulmaceae and Staphyleaceae. Important among these are ***Vernonia patens***, ***Lantana camara*** and three species of ***Lippia***.

Once established in the tree, the larva feeds on the pith. If the tree is very thick, a vertical gallery is constructed in the xylem, a few centimeters from the entrance. Feeding mainly takes place at night, then the larva moves backwards to the bag at the entrance where it defecates. The presence of wood chips in the bag is due to some bark removal.

The life cycle, which apparently takes a year, is completed inside the tree. The mature larva spins a membranous cover called an operculum at the mouth of the tunnel and pupates. Just before emerging, the pupa moves to the tunnel entrance, breaks the operculum, crosses over the bag and stays with its thorax on the outside. The recently emerged adult hangs from any surface to extend its wings. As far as it is known, pupation occurs at the beginning of the rainy season. However, most bags appear during August, September and October, suggesting that the larvae are in wild plants from April to August. The adult has a 4.2 cm wingspread with orange-brown forewings and light orange hindwings.

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As regards natural enemies, the hymenopteran ***Coccygomimus*** sp. (Ichneumonidae) has been reported to parasitize the pupae. The woodpecker ***Melanerpes hoffmannii*** is a predator of the larvae, but makes such deep holes when extracting them that the xylem is damaged and the tissue exposed to attack by pathogens.

Larva

Bag

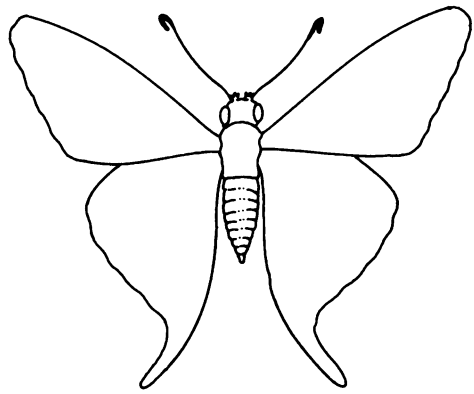
Adult

References: FORD, 1981; MORENO, 1989.

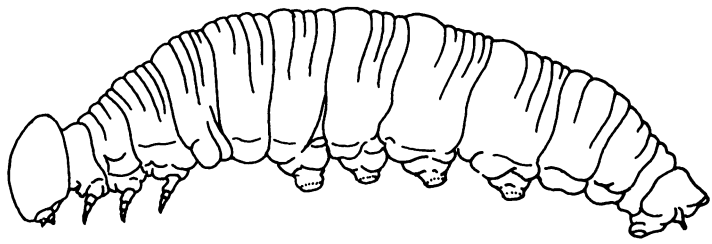
FAMILY HESPERIIDAE

The adults of this family are small, heavy-bodied butterflies with a 3-5 cm wingspread. The tips of the antennae are curved like a hook. The flight is erratic. The larva is 2-5 cm long, smooth with a large head and a sort of narrow collar. It generally folds leaves to make a hiding place from where it feeds. The leaves are stuck together with silk to form a cocoon for pupation.

In Costa Rica, ***Achyloides bursirus*** attacks ***Bombacopsis quinatum***, and in Honduras, an unidentified species defoliates ***Gliricidia sepium***.



Adult



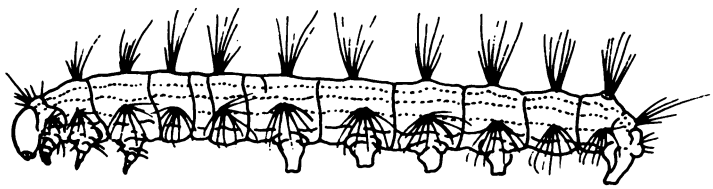
Larva

FAMILY LASIOCAMPIDAE

These are robust, medium sized moths with hairy bodies, legs and eyes. They are brown or grey with somewhat feathery antennae. They slightly resemble the Saturniidae, but have humeral veins in the hind wings.

The larvae are cylindrical or flat, measuring 2-8 cm and commonly have many hairs or setae. They feed in groups or as solitaries on the leaves of trees and shrubs of conifers and broadleaf species. They sometimes make large silk bags where they hide and pupate collectively. They make a cocoon for pupation.

In Costa Rica, ***Eutachyptera psidii*** defoliates ***Quercus copeyensis*** and ***Psidium guajava***, forming noticeable silk bags in both species. In Mexico it has been seen attacking ***Pinus*** spp.



Larva

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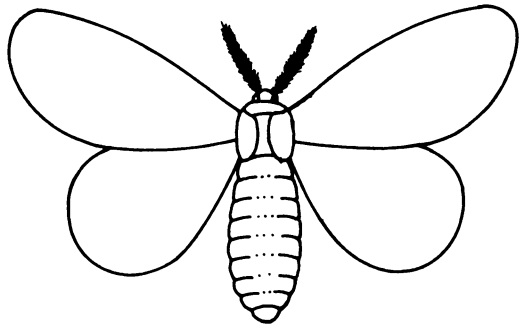
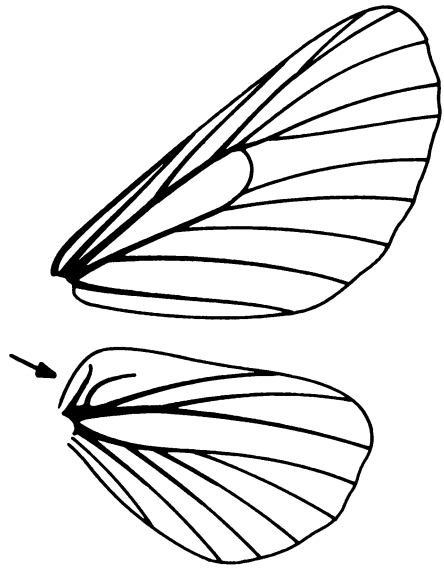
FAMILY LASIOCAMPIDAE



Adult



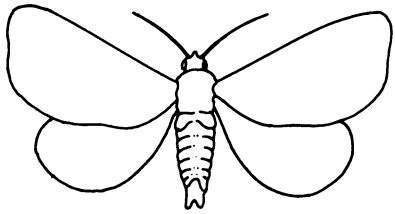
Humeral veins

References: CHAVERRI, 1983.

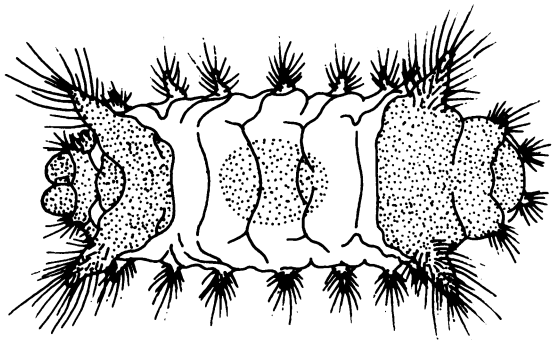
FAMILY LIMACODIDAE

The adults are small to medium sized moths with a 3 cm wingspread. The body is heavy and hairy and the wings brown. The larvae are short, fleshy and slug-like, lacking prolegs and with reduced thoracic legs. They feed on leaves.

In Costa Rica, two unidentified species defoliate ***Eucalyptus deglupta*** and ***Bombacopsis quinatum***, respectively.



Adult Limacodidae



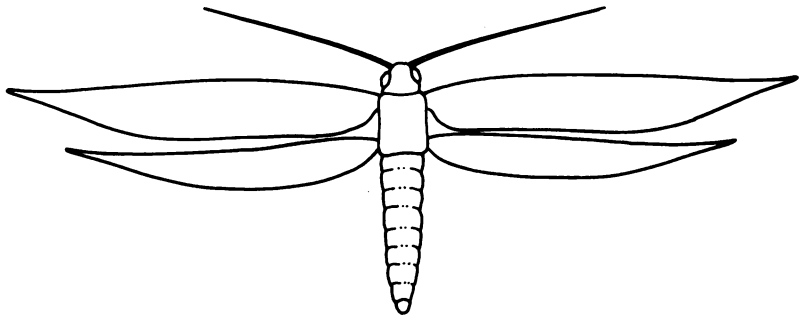
Larva

FAMILY LYONETIIDAE

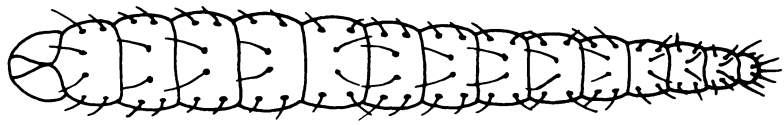
The adults are tiny moths, generally less than 8 mm, whitish and fragile looking. The forewings are very narrow and the hindwings are linear. They lack ocelli and maxillary palps.

The larvae measure 0.5-1 cm, are thin and the first instars appear flattened. Later instars are cylindrical. They vary in color from whitish to green or reddish purple. They are mainly leaf miners although some form galls or are stem borers.

In El Salvador, an unidentified species is a leaf miner in ***Cordia alliodora*** nurseries.



Adult



Larva

FAMILY NOCTUIDAE

The adults are dark colored, medium sized moths with a 25-50 mm wingspread. The larvae are smooth, dark and feed on leaves, flowers and fruit. Some feed on roots or stems of herbaceous plants or seedlings.

In Central America, several species such as ***Agrotis ipsilon***, ***A. subterranea***, ***A. malefida***, ***A. repleta***, ***Peridroma saucia*** and ***Spodoptera*** spp. destroy seedlings in nurseries and are known as cutworms. In Costa Rica, ***Cropia phila*** defoliates ***Cordia alliodora***. ***Mocis latipes***, after feeding on grasses, moves to ***Cordia alliodora*** where it folds the leaves and pupates. ***Coenipita bibitrix*** defoliates ***Enterolobium cyclocarpum***. In Honduras, ***Spodoptera*** sp. and another unidentified species defoliate ***Gliricidia sepium***.

In some Caribbean countries, the defoliator ***Hyblaea puera*** attacks ***Tabebuia pentaphylla*** and ***Vitex parviflora***. In Asia, Australia and the Pacific it damages ***Tectona grandis*** and other dicotyledonous trees. In India, ***Plecoptera reflexa*** defoliates ***Dalbergia sissoo*** and ***Eligma narcissus*** attacks ***Ailanthus*** spp.

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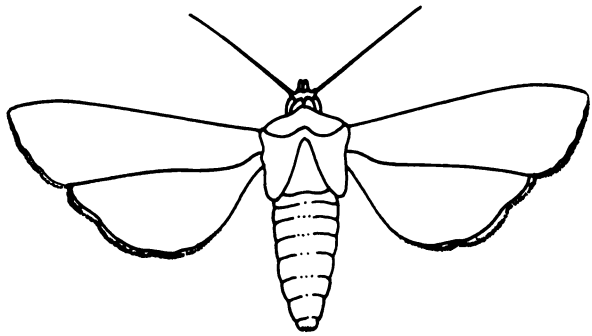
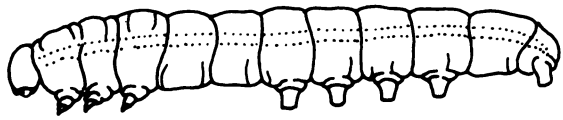
FAMILY NOCTUIDAE



Adult



Larva

References: FORD, 1981; JANZEN, 1983a; KING & SAUNDERS, 1984; NAIR, 1986.

Agrotis spp.

Although other noctuids and other families of moths, such as the Pyralidae, have cutworm larvae, the genus ***Agrotis*** includes some of the most common and problematic cutworms. In Central America there are four species: ***Agrotis ipsilon***, ***A. malefida***, ***A. repleta*** and ***A. subterranea***. These four, although different in many aspects, have much in common.

The larvae pass through five instars. During the first three instars they feed on leaves that are close to the soil. The last two larval instars are the most important economically (both for forestry and agriculture) since the larvae affect young plants, fruits in contact with the soil, bulbs and tubers. They are a permanent problem in forestry nurseries on nearly all species. They cut seedlings at soil level or at 1-2 cm height and feed on the leaves of the broken stem. At other times, the larva may climb the stem to feed on the leaves directly.

The larvae are dark, usually brown, grey or black, measuring 4-5 cm long. They are nocturnal and during the day hide in the soil close to the feeding site. When they are disturbed, they curl up. They pupate under the soil in a cell made of loosely packed soil. The pupa measures 2 - 3 cm and is brown or bronze and shiny. The adult is also darkly colored, brown, grey or black, with a wingspread 35 - 50 mm. The life cycle may be completed in 32 - 69 days, depending on species and environmental conditions.

As natural enemies, besides there are several species of wasps, beetles and bugs which are predators, dipteran (Tachinidae) and hymenopteran (Braconidae, Ichneumonidae) parasitoids.

The geographic distribution is wide, and for some species covers almost the entire American continent.

...

Agrotis spp.

Larva

Adult

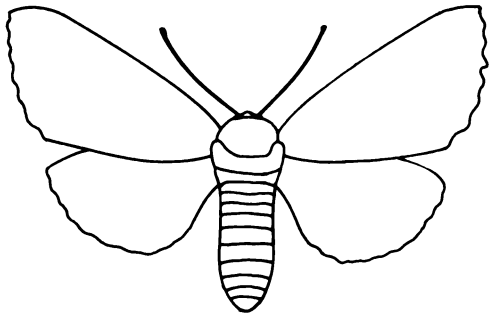
References: KING & SAUNDERS, 1984.

FAMILY NOTODONTIDAE

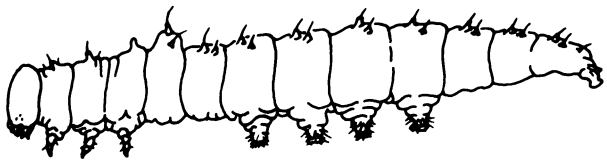
The adults of this family are somewhat heavy bodied, medium sized moths, with a wingspread normally less than 5 cm. The wings are strong and not very wide. The entire body is covered with hair which is longer on the femurs. They are brownish or yellowish. They appear similar to the Noctuidae, but the wing venation differs. In some species there are tufts of hair on the hind margin of the fore wings, which protrude when the wings are folded.

The larvae are large or medium sized (2.4-9.5 cm) with a somewhat rounded or flattened head. The rest of the body is cylindrical and without hairs, but there are often tubercles on the dorsal surface. When disturbed, they often elevate the posterior and anterior ends of the body and stay in this position, attached to the substrate by the prolegs. They feed on the leaves of trees and shrubs, usually openly, although some species fold the leaves and hide in them.

In Costa Rica, ***Lirimiris truncata*** and ***L. ligniteca*** have been seen defoliating ***Guazuma ulmifolia*** and ***Bombacopsis quinatum*** respectively.



Adult



Larva

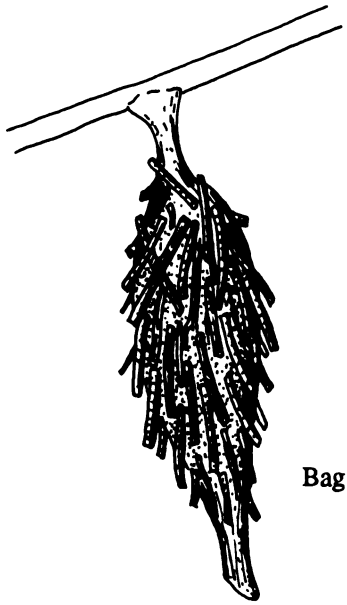
References: JANZEN, 1983a.

FAMILY PSYCHIDAE

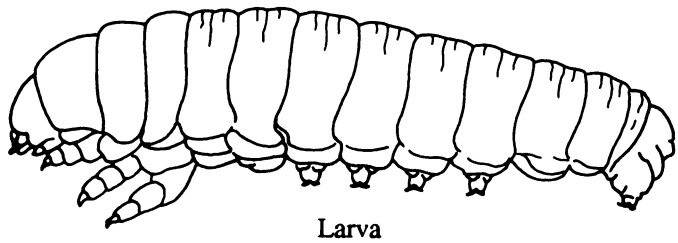
The larvae of this family live in characteristic bags or cases made of small twigs stuck with silk threads. They remain in the bags to feed on leaves and pupate. The males are tiny and have well developed wings. The females lack wings and legs, appearing worm-like, and only live to reproduce.

In Costa Rica, an unidentified species defoliates ***Cupressus lusitanica.***

In India, ***Pteroma plagiophleps*** defoliates ***Albizzia falcataria*** trees.



Bag of psychid



Larva

References: NAIR, 1986.

FAMILY PYRALIDAE

The adults are moths of variable morphology. They are usually small with a wingspread rarely greater than 40 mm. The wings are delicate, long and triangular. The labial palps often protrude anteriorly. The larvae almost always feed in concealed areas, boring into flowers, fruits, pods, seeds, buds, shoots, stems, roots and leaves. Those that feed on leaves usually fold them to conceal themselves.

In Central America, the most important species are ***Hypsipyla grandella*** and ***H. ferrealis***, which attack several species of Meliaceae and ***Dioryctria*** spp. which attack several species of ***Pinus***. In Costa Rica, ***Elasmopalpus lignosellus*** destroys ***Bombacopsis quinatum*** seedlings, ***Ectomyelois muriscis*** is a seed borer of ***Hymenaea courbaril***, ***Eulepte*** sp. defoliates ***Tabebuia rosea***, ***Terastia meticulosellus*** is a shoot borer of ***Erythrina*** spp. and ***Aganthodes monstralis*** is a defoliator of ***Erythrina poeppigiana***. In Honduras, an unidentified species defoliates ***Gliricidia sepium***.

In some Caribbean countries, ***Dioryctria clarioralis*** is a bud borer of ***Pinus caribaea*** and ***D. horneana*** attacks buds and the trunks of ***Pinus*** spp. ***Conchylodes diptheralis*** defoliates ***Cordia alliodora*** and ***Anypsipyla univetella*** and ***Bonchys munitalis*** attack seeds of ***Tabebuia pentaphylla***. In Brazil, ***Elasmopalpus lignosellus*** attacks seedlings of ***Araucaria angustifolia*** and ***Laspeyresia araucariae*** attacks its buds and fruits.

In Mexico there are seven species of ***Dioryctria*** and one of ***Herculia*** which attack the cones of ***Pinus*** spp. In India, ***Pagyda salvalis*** attacks flowers of ***Tectona grandis*** and ***Eutectona machaeralis*** attacks its leaves. In southeast Asia, Australia and Madagascar, ***Hypsipyla robusta*** attacks Meliaceae such as ***Toona ciliata*** and ***Swietenia macrophylla***.

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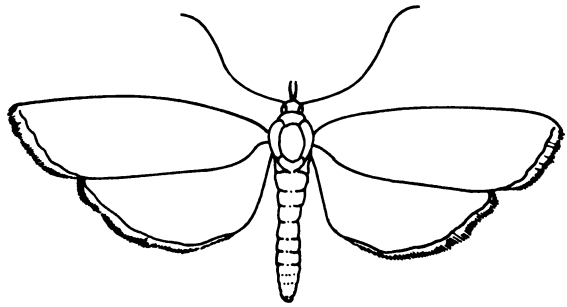
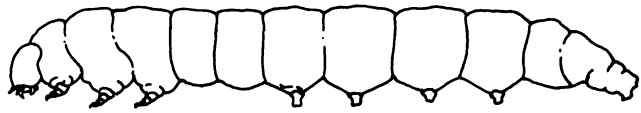
FAMILY PYRALIDAE



Adult



Larva

References: CIBRIAN *et al.*, 1986; GALLO *et al.*, 1978; JANZEN, 1983b; SEN-SARMA, 1986

Dioryctria spp.

Dioryctria larvae are specific pests of conifers and are frequently found in North America, where there are 21 species. In Honduras, Guatemala and the Caribbean they attack several species of ***Pinus***. Their biology is so variable that it is hard to find characteristics shared by all members of the genus.

The adults are medium sized moths with 19-34 mm wingspread. The forewings are predominantly reddish brown, grey-brown or dark grey and contrast markedly with the lighter hind wings which are grey, cream or light brown. The forewings are commonly marked with wavy, transverse bands of white or light grey and there may be a pale discal mark close to the outer margin. Some species have raised scales which contrast with the flat scales on the rest of the wing.

Dioryctria spp. cause multiple damage. They generally attack cones more than one year old, although they can affect younger cones, shoots, buds and the phloem of the trunk and branches. Some species attack the galls produced by the fungus ***Cronartium conigenum*** in cones and branches.

In Central America, the most important species are ***D. erythropasa*** and ***D. majorella*** which attack ***Pinus oocarpa***, ***P. caribaea*** var. ***hondurensis*** and ***P. maximinoi***. In Mexico, ***P. oocarpa*** is also attacked by ***D. pinicolella*** and ***D. cibriani***.

The larva of ***D. erythropasa*** is brownish in the first instars and bright green with dark brown apodemal holes when mature. It measures from 18 to 20 mm.

It bores cones and builds a gallery that may only extend to the area with seeds or may penetrate to the shaft. The cones turn brown or reddish and die. The larva may also attack galls or tumors induced by ***Cronartium*** sp. From the outside, the damage can be detected from the reddish piles of frass, consisting of resin, excrement and silk, found between the scales of the cones. Beneath each pile, there is an oval hole, 3-4 mm in diameter, which is the entrance to the gallery. This is generally free of resin and occasionally contains fine, compact excrement. The larva may often destroy more than one cone to complete its development. Pupation takes place in the cone.

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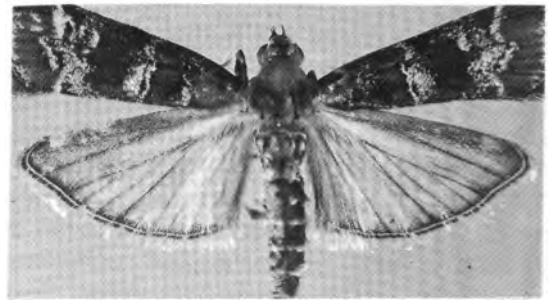
D. majorella larvae show a marked preference for cones and branches infected with ***Cronartium*** sp. although they will also attack healthy cones and branches. Pupation occurs in the soil. The mature larva measures 17-18 mm long and is light red with pale yellow spots surrounding the tubercles which are brown. The feeding habits and damage are very similar to ***D. erythropasa.***

Other species such as ***D. clarioralis*** and ***D. horneana***, both present in Cuba, have different habits from those mentioned. The first builds galleries up to 10 cm long in new shoots of ***Pinus caribaea***. It attacks these from the bottom working up to the top so that they fold downwards as they die. ***D. horneana*** attacks cones, shoots (from top to bottom) and trunks of three species of ***Pinus***. In the trunk, the larva develops in the phloem and can cause serious fractures.

Damage



Adult

References: CARLIN & NUÑEZ, 1985; CIBRIAN *et al.*, 1986; HOCHMUT & MANSO, 1982

Elasmopalpus lignosellus

The larva of this moth often contorts itself and even jumps back when disturbed, giving it the local name "jumping caterpillar". It is essentially an agricultural pest attacking corn, rice, beans, sorghum, sugar cane, groundnuts and cowpeas. It can appear in forestry nurseries where it attacks the seedlings of species such as ***Bombacopsis quinatum***. In Brazil it attacks ***Araucaria angustifolia***. It is commonly found in well drained, sandy soils, especially during the dry season.

Another characteristic of the larva is the construction of a tube of sand and silk, which allows it to move from the underground tunnel where it lives to the seedlings, without being exposed. The walls of the tunnel are also lined with silk and remains of partially consumed vegetable matter can be found towards the bottom. In agricultural crops, the larva bores into the stems causing wilting and death. In the case of ***Bombacopsis quinatum***, the seedlings' roots are consumed, the base is cut and the stem and leaves are progressively eaten until no trace remains.

The adult female lays eggs singly or in groups on the soil at the base of the plants, or on nearby leaves and stems. The eggs are pale green and take 3-7 days to hatch. The larva passes through six instars taking 13-24 days. The mature larva measures about 15 mm, is grey- or blue-green with a dark, almost black, head. The prothoracic plate and other plates on the thorax are also dark, almost black. Pupation occurs within the sandy tube. The pupa is initially green, but later turns dark brown. It measures 10 mm and takes 6-11 days to complete development. The adult moth has a 15-20 mm wingspread and has long, feathery labial palps. In both sexes the hindwings are light grey, but the forewings differ, the females having black and the males brownish yellow forewings with grey margins.

As natural enemies, the insect has several parasitoids such as hymenopterans from the Braconidae, Eulophidae and Ichneumonidae families and dipterans from the Tachinidae family.

It has a wide geographic distribution from the U.S. to South America, including several Caribbean countries.

...

Damage

Larva

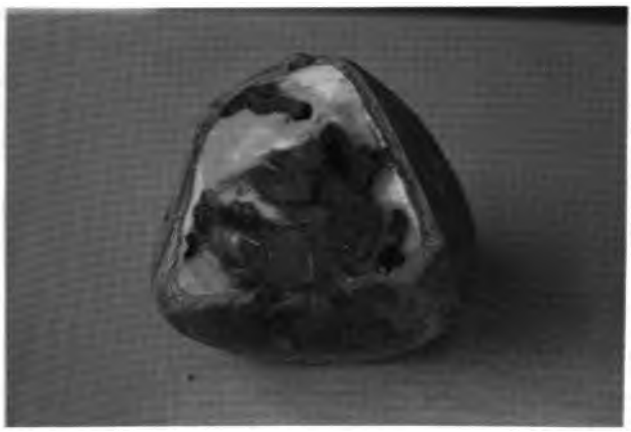
References: GALLO *et al.*,1978; KING & SAUNDERS, 1984.

Hypsipyla ferrealis

Morphologically, this species closely resembles ***Hypsipyla grandella***, and can easily be confused with it. It attacks the fruits and seeds of ***Carapa guianensis***, although there may be other wild hosts. Under laboratory conditions, the female produces up to 570 eggs. These are elliptical in shape and cream colored, later turning red. On emergence, the larva is cream colored with a black head and thoracic plate. The larva gradually changes color through off white, light cream, cream, pale pink, blue-green and finally a greenish blue. The pupa is light chestnut ventrally and dark chestnut dorsally, measuring 13-16 mm. The adult male has a wingspread 22-32 mm and the female 24-36 mm. The thorax is pale chestnut with dark grey scales and the forewings are light grey-chestnut with a slight violet luster and a pale mark in the center. The hindwings are semi-transparent, light grey in the male and dark chestnut with a violet luster in the female. The abdomen is greyish chestnut dorsally and pale chestnut ventrally. The hindwings are darker than those of ***H. grandella.***

The larva is parasitized by the hymenopteran ***Hypomicrogaster hypsipylae*** (Braconidae), which is gregarious.

This species has been reported in Central America, Colombia, Venezuela, French Guiana, Brazil and Trinidad.



Damage

References: BECKER, 1976.

Hypsipyla grandella

The larva of this insect attacks several species of plants from the family Meliaceae: ***Cedrela mexicana, C. odorata, C. angustifolia, C. tonduzii, C. salvadorensis, C. fissilis, C. lilloi, C. tubiflora, Swietenia macrophylla, S. mahagoni, Carapa guianensis, C. procera, Guarea caoba, G. trichilioides, Khaya senegalensis, K. nyasica*** and ***Trichilia*** sp..

The eggs measure 0.5 mm, are eliptical, flattened, pale yellow turning red. They are normally laid on young green buds, although they may also appear on petioles of leaves, leaflets and fruits. The newly emerged larva is pinky beige and measures 2-2.5 mm. The final instar larva measures 21-27 mm and is pale blue, dark blue or pale pink. The pupa is about 13 mm long, chestnut ventrally and darker on the dorsal surface. The adult has a 22-40 mm wingspread and the head, thorax and abdomen are grey. The forewings are grey with a violet lustre and reddish chestnut scales and a pale mark in the center. The hindwings are white, semi-transparent and somewhat iridescent.

This pest's attack is generally most severe in young (two or more years old) trees growing in areas exposed to sunlight. The larva develops in new branches where it feeds on the bark and pith and in fruits where it feeds on the seeds and internal tissues. Greatest damage results from the perforation of new buds, especially the terminal bud, where it bores a gallery sometimes more than 25 cm long. As a result, the terminal bud is deformed or branches, reducing the commercial value of the tree. Repeated attacks can result in stunted growth and even the death of the tree. Externally, damage can be recognized by the drying of the terminal bud and piles of reddish frass (sawdust, silk and excrement) on the stem. The larva pupates in the branch or fruit where it developed, protected by a silk cocoon. It may move to another branch or fruit to finish its development if the food supply runs out at the original site.

Although much available information is contradictory, the life cycle appears to take 80-95 days in the rainy season and 63-80 days in the dry season. This means that there can be several generations a year. On the other hand, there is an overlap of generations since the species is always active and in different stages of development.

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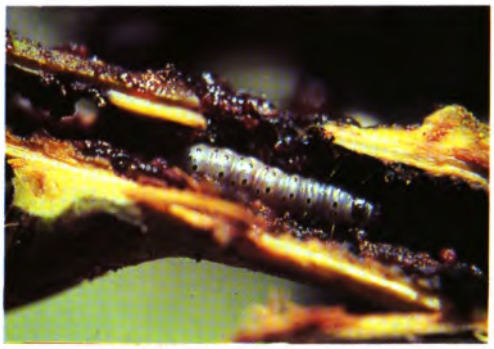
The larvae are parasitized by wasps from several families, flies of the Tachinidae family and the nematode ***Hexamermis albicans.***

The species has a wide geographic distribution from Florida (USA) to Argentina, including the Caribbean islands.

Frass pile



Larva

Adult

References: BECKER, 1976; BROWNE, 1968; HOCHMUT & MANSO, 1982.

FAMILY SATURNIIDAE

The adults of this family are large, heavy-bodied moths with a wingspread up to 25 cm. The wings are nearly always conspicuously or brightly colored and many have transparent eyespots. The larvae are defoliators. They are large with many tubercles or spines, some of which can cause irritation. Although some pupate in the soil without a cocoon, many spin large cocoons, sometimes collectively, attached to leaves and small branches on the tree or on the leaf litter below it.

In Costa Rica and Panama, ***Arsenura armida*** defoliates ***Bombacopsis quinatum***. In Costa Rica, the same species is defoliated by ***Caio championi*** and ***Periphoba arcaei***, the latter also attacking ***Guazuma ulmifolia*** and other species. ***Automeris rubrescens*** defoliates ***Gmelina arborea***, ***Guazuma ulmifolia***, ***Cordia alliodora*** and six other species; ***Automeris janus*** defoliates ***Juglans olanchana***; ***Lonomia electra*** attacks ***Gmelina arborea***; ***Hylesia lineata*** damages ***Guazuma ulmifolia***, ***Gliricidia sepium*** and ***Hymenaea courbaril***; ***Dirphia avia*** attacks ***Cedrela odorata*** and ***H. courbaril***; ***Dirphiopsis flora*** damages ***Quercus*** aff. ***seemannii***. In Guatemala, ***Hylesia*** sp. attacks ***Cupressus lusitanica*** and four species of ***Pinus***.

In Australia, ***Synthereta janetta*** defoliates ***Eucalyptus deglupta***

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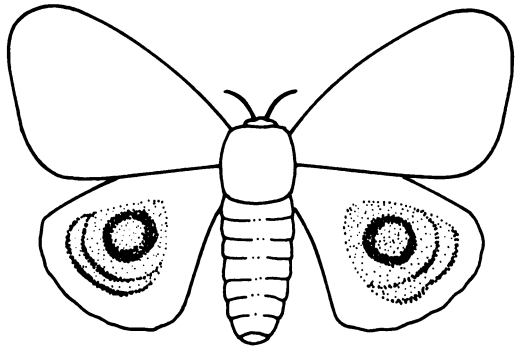
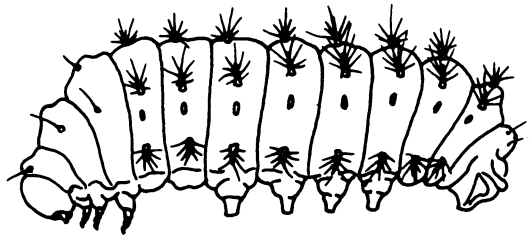
FAMILY SATURNIIDAE



Adult



Larva

References: JANZEN, 1982; CHAVERRI, 1984; HILJE & QUIROS, 1986.

Arsenura armida

The larva of this moth has a showy coloration of alternating black and green bands with a thin, pale yellow band separating them. The anterior and posterior ends are reddish. The first instars have two pairs of black filaments on the dorsum of the thorax and one pair on the penultimate abdominal segment. The mature larva can measure up to 13 cm long and 2 cm in diameter.

In ***Bombacopsis quinatum*** plantations and isolated trees on open ground, massive numbers of these larvae can be found causing severe defoliation. They are gregarious and rest in groups during the day, the young larvae on the leaves and the mature larvae between the spines of the trunk. They feed at night and when they move between trees they travel in file.

The mature larva pupates in a small chamber at the base of the tree amongst the leaf litter. The pupa is black and smooth, measuring 5 cm long and 2 cm in diameter. During the rainy season pupation lasts a month, at other times it can take up to five months. There are normally two generations a year.

The adult shows sexual dimorphism. The male is dark brown with bipectinate antennae whilst the female is yellowish brown with filiform antennae and a fatter abdomen. Both sexes are heavy bodied with a wingspread of about 12 cm. Both the thorax and abdomen are hairy. The wings have three, differently colored longitudinal bands. The internal band is very wide and separated from the middle band by an almost straight line. The middle band is separated from the outside band by a wavy double line. There is a clear, almost transparent spot like a window close to the apex of the forewing.

Winthemia pinguioides (Tachinidae) and ***Sarcodexia sternodontis*** (Sarcophagidae) are natural enemies.

This species is found in warm areas below 1500 meters above sea level, from Mexico to southern Brazil. Within this area it also attacks ***Guazuma ulmifolia***, ***G. tomentosa***, ***Luehea candida***, ***Annona montana*** and ***Theobroma cacao***.

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Arsenura armida

Young larva

Mature larva

Adult female

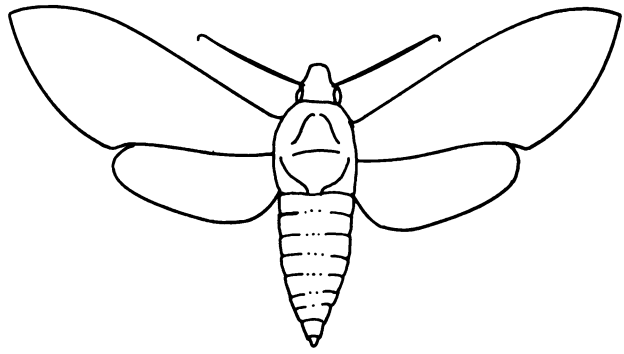
References: BRICEÑO & RAMIREZ, 1976; JANZEN, 1982.

FAMILY SPHINGIDAE

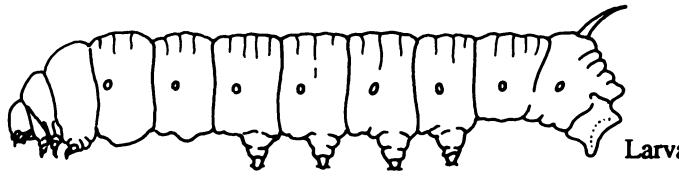
The adults are large, heavy bodied moths with a wingspread up to 13 cm. The body is somewhat conical in shape and the forewings are elongated and narrow with an oblique external margin. The proboscis is very long, the same length or longer than the body (up to 25 cm in some species) and is normally kept rolled up. The antennae are slightly thickened towards the middle or apex and are hooked. They are strong fliers and can hover over flowers extracting nectar with the long proboscis, rather like hummingbirds.

The larvae also show easily recognized characteristics. They are normally large (some measure up to 10 cm), cylindrical, hairless and frequently green. There is a distinct, curved "horn" or sometimes just a tubercle on the eighth abdominal segment. They feed on the leaves of herbaceous plants, trees and shrubs. They pupate in the soil. Some species spin a cocoon, but most are naked, the pupa shaped like a pitcher with the proboscis appearing like the handle.

In Honduras, ***Erynnis*** sp. defoliates ***Gliricidia sepium*** and species such as ***E. alope*** and ***E. ello*** attack ***Carica papaya*** and ***Manihot esculenta***



Adult



Larva

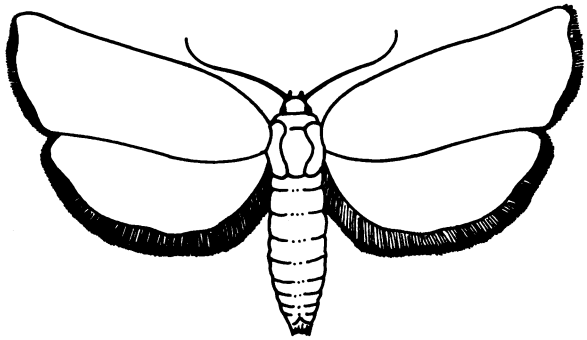
References: KING & SAUNDERS, 1984.

FAMILY TORTRICIDAE

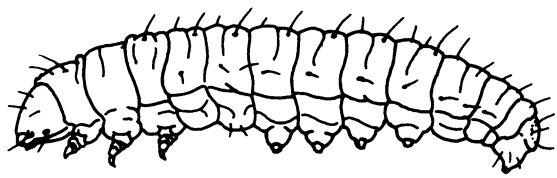
The adults are very small moths with a wingspread rarely greater than 25 mm. They are brown or grey with marbled areas or spots. The forewings have an L shaped apex. The larvae feed on fruit, nuts, seeds, cones, buds and leaves. Those that feed on leaves normally roll or fold them to make pupation sites, otherwise they spin cocoons under the bark of trees or in leaf litter.

Within this family there is a subfamily, Olethreutinae, which some authors consider a family (Olethreutidae). The adults of these can be distinguished by the fringes of long hairs at the posterior margins of the hindwings. ***Rhyacionia frustrana***, the Nantucket Pine Tip Moth which is common in all Central American countries and ***R. subtropica***, seen in Guatemala, belong to this subfamily. In Honduras, ***Argyrotaenia*** sp., ***Cydia*** sp. and ***Satronia*** sp. attack cones of several species of ***Pinus*** and two unidentified species defoliate ***Gliricidia sepium*** and ***Leucaena leucocephala.*** In Guatemala another species attacks ***Caesalpinia velutina.***

In some Caribbean countries, ***Gymnandrosoma pithecolobiae*** attacks seeds of ***Samanea saman.***



Adult



Larva

References: CARLIN & NUÑEZ, 1985.

Rhyacionia frustrana

The larva of the Nantucket Pine Tip Moth is specific to pines and attacks species such as ***Pinus caribaea***, ***P. oocarpa***, ***P. taeda***, ***P. banksiana***, ***P. echinata***, ***P. cubensis***, ***P. occidentalis***, ***P. elliottii***, ***P. canarensis***, ***P. kesiya*** and ***P. radiata***.

The female usually lays eggs on the upper part of new buds. The newly emerged larva nearly always bores into the tissue at the base of the needles, causing the secretion of a whitish resin that is readily seen. At the same time it spins a fine web on the spine of the needle and feeds on the tender bud tissue below it. The more mature larva also attacks the shaft of the bud, making galleries 2-3 cm long. This causes drying of the bud which turns reddish brown, covered in resin. The tree responds to the damage by producing two to six new buds which result in subsequent branching or deformation of the trunk and retarded growth. Repeated attack can cause the death of the tree. Attacks can occur to nursery seedlings and in saplings up to 3 m in height. It appears that the moth cannot fly higher than 3 m so that taller trees are not attacked. This species can also attack the cones of its host.

The egg is flattened, yellow or reddish yellow and measures 0.5 mm in diameter. The first instar larva is pale yellow with a black or light brown head and measures 1.5 mm in length. The mature larva is orange-yellow and can measure up to 10 mm. Pupation takes place in the bud and the pupa is brown, measuring between 5 and 7 mm. The adult moth has silver grey forewings, with reddish brown or brick-red markings and a wingspread of 10-13 mm. Development takes 6-9 days for the egg, 19-23 days for the larva, 11-14 days for the pupa and 5-7 days for the adult. In Central America there are probably more than eight generations a year since development is uninterrupted and specimens of all stages can be found at any time of year. In general, damage is most severe during the dry season.

Several species of wasps are parasitoids of the larvae: ***Elachertus*** sp., ***Habrocytus*** sp., ***Pteromalus*** sp., ***Parasierola*** sp., ***Spilochalcis*** sp., ***S. side.***, ***Tetrastichus*** sp., ***Goniozus*** sp. and the fly ***Lixophaga*** sp..

The geographic distribution is wide including Canada, the U.S., Mexico, Central America and several Caribbean islands.

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Rhyacionia frustrana

Damage

Larva

Adult

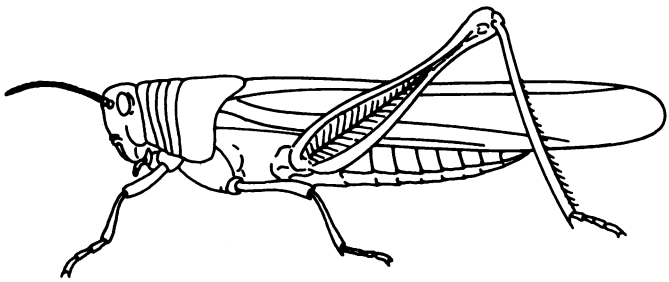
References: BROWNE, 1968; FORD, 1986a; HOCHMUT & MANSO, 1982; SALAZAR, 1984.

ORDER SALTATORIA

FAMILY ACRIDIDAE

These are locusts with short antennae. The auditory organ is located at the sides of the first abdominal segment. The tarsi have three segments and the prosternum (ventrum of the first thoracic segments) has a prominent spine or tubercle.

In Central America, the most important species is ***Schistocerca piceifrons***, the migratory locust, which defoliates many agricultural crops and some important forestry species.



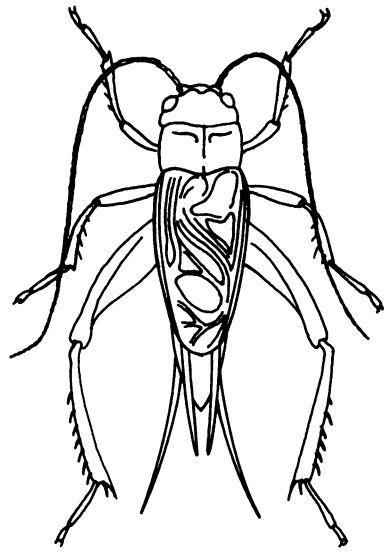
Adult

References: KING & SAUNDERS, 1984.

FAMILY GRYLLIDAE

These are commonly called long-horned grasshoppers because of their long, filiform antennae. The tarsi have three segments and the auditory organs are located on the tibia of the forelegs. During the day, they hide in holes dug in the ground or in litter. They emerge at night to feed.

The most important species in Central America is ***Acheta assimilis*** which cuts the stems of nursery seedlings and feeds on roots and leaves. This species also damages crops such as rice, corn and beans.



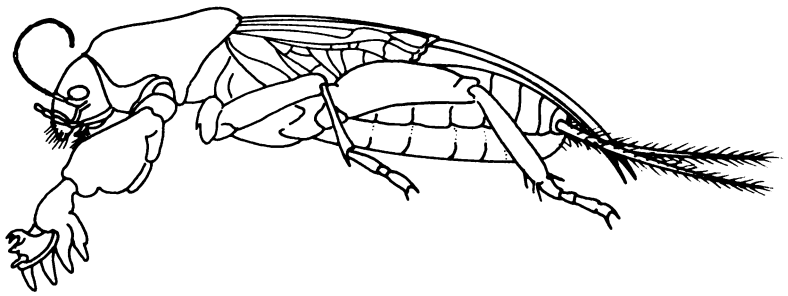
Adult

References: KING & SAUNDERS, 1984.

FAMILY GRYLLOTALPIDAE

This family comprises the "mole crickets" which can be recognized by the forelegs adapted for digging. These legs are flattened like spades and have teeth or knife-like appendages to assist in digging long, shallow tunnels. These tunnels reach the roots of plants on which the mole cricket feeds.

In Central America, the most important species is ***Neocurtilla hexadactyla*** (formerly ***Gryllotalpa hexadactyla***) which can affect nursery seedlings and is a serious pest in rice and potatoes.



Adult

References: KING & SAUNDERS, 1984.

ORDER THYSANOPTERA

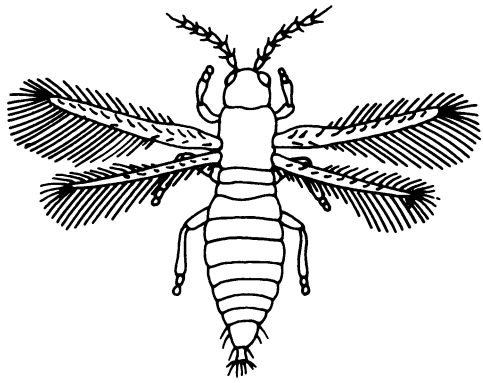
FAMILY THRIPIDAE

The adult thrips are tiny, rarely measuring more than 2 mm long. The wings are needle-like and fringed.

The female lays eggs in the host plant tissue by means of a sharp ovipositor. During the first two instars, the nymphs stay in groups with the adults. The third and fourth instar nymphs do not feed.

Nymphs and adults pierce the epidermis of the plant with their single mandible, rupture the cells with the maxillary stylets and suck the sap with their conical mouthparts. Drops of honeydew frequently appear at the posterior end, as in the case of sap sucking homopterans which consume more than their requirements.

In Costa Rica, ***Selenothrips rubrocintus*** has been observed feeding on leaves of ***Eucalyptus deglupta***. This species also affects ***Theobroma cacao*** and ***Psidium friedrichsthalianum***.



Adult

2. VERTEBRATES

Orthogeomys spp.
(Rodentia: Geomyidae)

Pocket gophers are rodents with a distribution limited to the northern part of the American continent. Of the various genera (***Geomys***, ***Pappogeomys***, ***Thomomys***, ***Zygogeomys*** and ***Orthogeomys***) only the last is represented in Central America. The species encountered are: ***O. hispidus*** (Guatemala and Belize); ***O. grandis*** (Honduras); ***O. matagalpae*** (Honduras and Nicaragua); ***O. heterodus***, ***O. cherriei*** and ***O. underwoodi*** (Costa Rica); ***O. cavator*** (Costa Rica and Panama) and ***O. dariensis*** (Panama).

They have stout, rounded bodies with a very short neck. The legs are short and the paws end in long, sharp, curved claws. The front claws are especially long and sharp. The coat is rough and short, dark brown, grey or black with white marks or bands in some species. The sense of smell is well developed and the short, hairless tail and whiskers are very sensitive to touch. The eyes are small and the ears reduced. The incisors are very large and exposed, covered in a layer of deep yellow enamel. The lips can close behind the incisors to avoid swallowing soil as they gnaw. The cheeks have large pouches for storing food. The total length (including the tail) varies between 17 and 40 cm and they weigh between 500 and 800 g.

Pocket gophers are subterranean, burrowing animals which rarely come up to the surface. They prefer to live in deep, sandy, rock-free soil with good drainage. They build large nests (sometimes 110 cm long, 60 cm wide and 30 cm high) to store food, defecate and reproduce. Tunnels stretch in all directions from the nest, subdividing into secondary tunnels. These are used by the animal to reach food. As new tunnels are dug, the gopher fills in the old ones with leftover soil and pushes some to the outside. Hence little piles of fresh soil can be observed at the animal's feeding sites. The secondary tunnels are between 6 and 10 cm deep with a diameter of 8 cm. The gallery system of one individual can cover an area of 256 m^2.

Pocket gophers are diurnal and most active between 8 a.m. and 2 p.m. with a peak of activity around midday. They are generally solitary, only sharing their nests and galleries during mating and when rearing offspring. Some species seem to show territoriality. They produce 2-4 litters a year, each with 2-4 offspring. The gestation period is 20-32 days.

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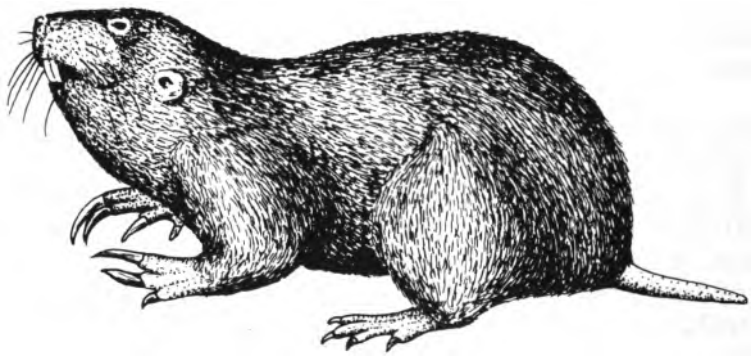
Orthogeomys spp.
(Rodentia: Geomyidae)

They are polyphagous, feeding on tubers, succulent roots, tender stems and fruit and leaves that hang close to the ground, in at least twenty agricultural crops. In the area of forestry, they affect several species: ***Cupressus lusitanica***, ***Pinus*** spp., ***Cedrela odorata***, ***Eucalyptus*** spp., ***Juglans olanchana***, ***Gliricidia sepium***, ***Erythrina*** spp., etc. Most damage occurs as root destruction in saplings and the consumption of seedlings, but the roots of larger trees can be gnawed to such an extent that the tree topples over.

Amongst the most common predators are weasels (***Mustela frenata***), raccoons (***Procyon lotor***), coatis (***Nasua nasua***), coyotes (***Canis latrans***), boas (***Boa constrictor***) and some birds of prey. Of these, only the boas and weasels can enter the gopher's galleries.



Orthogeomys sp.

References: ARANDA & MARCH, 1987; DELGADO, 1986; HALL, 1981; McPHERSON, 1985; MORA & MOREIRA, 1984; NOWAK & PARADISO, 1983; SISK & VAUGHAN, 1984; TIMM, 1983.

Sciurus spp.
(Rodentia: Sciuridae)

Although there are other genera of squirrels in Central America (e.g. ***Microsciurus*** and ***Syntheosciurus***), ***Sciurus*** is the most relevant and the best represented with six species. Some may be found in only one country, although their distribution is wide. ***Sciurus aureogaster*** and ***S. yucatanensis*** appear in Guatemala, ***S. richmondi*** in Nicaragua, ***S. granatensis*** in Costa Rica and Panama. ***S. deppei*** occurs in all the countries excepting Panama and ***S. variegatoides*** is the only species in common. The latter has 15 subspecies.

Squirrels have a svelte body, 43-56 cm long, half of this length being tail, and weigh between 450 and 600 g. The coat is short, fairly rough and of variable color, although reddish brown and rusty red predominate. The tail is flattened with longer hairs than the rest of the body.

They are very agile animals. Their long sharp claws allow them to quickly climb up and down trees and the tails assist in jumping between them. They are normally arboreal, occasionally descending to the ground. They nest in holes in trees or make large nests of leaves and twigs in the forks or high branches of trees. They carry food in their cheek pouches and store it in their nests.

Squirrels are polyphagous, feeding on flowers, fruits, seeds, nuts, tender buds, leaves, stems, tree bark, fungi, insects and even birds' eggs and nestlings. They are serious pests of many crops, such as corn, rice, cacao, coconut, macadamia nut, mango, avocado, peas, chayote, carrots, pawpaw and bananas. They also damage trees of forestry importance, such as ***Bombacopsis quinatum***, ***Cupressus lusitanica*** and ***Eucalyptus*** spp., by gnawing bark off the trunk and branches. This produces irreparable breaks in the trees and opens the tissue for pathogen attack.

Information on squirrel reproduction is scant and contradictory. However, most activity seems to take place in the dry season, the gestation period is 40-45 days and they produce 1-2 litters per year, each with 2-3 offspring.

They are usually diurnal and feed alone or in groups. Territoriality exists in some species. Although squirrels normally inhabit forest areas, some, such as *S. variegatoides* easily adapt to disturbed areas.

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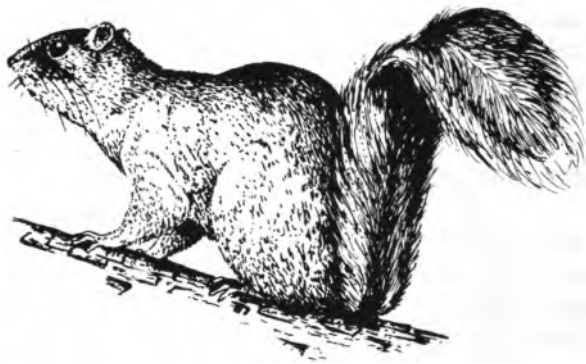
Sciurus spp.
(Rodentia: Sciuridae)



Sciurus sp.

References: HALL, 1981; McPHERSON, 1985; MENDEZ, 1970; MONGE, 1989; MORA & MOREIRA, 1984; NOWAK & PARADISO, 1983.

Sigmodon hispidus
(Rodentia: Cricetidae)

Known as the hispid cotton rat, this animal measures between 22 and 37 cm long and weighs between 100 and 200 g. The tail is broad and shorter than the body. The eyes are large and the ears are reduced, partially covered in hair. The coat is grey with brown tones and is rough and bristly in appearance.

This rat is very active during daylight hours. It runs along the ground following its trails or in shallow tunnels that it digs for up to 3 m. It builds its nest at the base of clumps of grass or in cracks in the soil, lined with dry grass. It prefers to live in areas with ample cover from herbaceous plants and shrubs. It has a high reproductive potential since the gestation period lasts less than a month. Each litter has 2-12 young (5 or 6 average) which can, in their turn, reproduce in 45 days.

Although it can feed on insects, birds' eggs and nestlings, it is mainly herbivorous, feeding on roots, stems, shoots, fruits and seeds. It is a serious pest of crops such as sugar cane, corn and rice. It can strip the bark from trees such as ***Bombacopsis quinatum*** and ***Gmelina arborea.*** If the damage occurs at the base of the tree, it can result in death. It is thought that the rat attacks the bark not for its nutritional value but to obtain water in the dry season and to wear down its incisor teeth.

In Central America, the rat is always present to some extent, but population densities reach alarming levels every five years for, as yet, unknown reasons.

Its distribution ranges from the southern U.S. to the north of Venezuela and northeast Peru.

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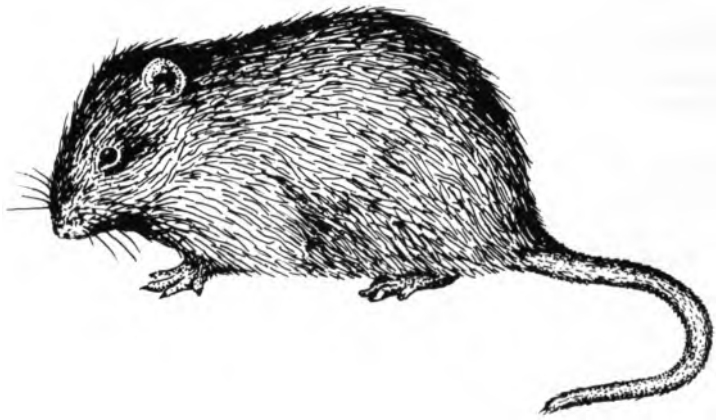
Sigmodon hispidus
(Rodentia: Cricetidae)



S. hispidus

References: ARANDA & MARCH, 1987; HALL, 1981; JANZEN, 1983; McPHERSON, 1985; MORA & MOREIRA, 1984; NOWAK & PARADISO, 1983; TIMM, 1983.

Sylvilagus spp.
(Lagomorpha: Leporidae)

The Leporidae family contains two rabbit species (***Sylvilagus brasiliensis*** and ***S. floridanus***) which can be important from the forestry point of view since they attack nursery seedlings and recently transplanted saplings. They also destroy the bark of trees and shrubs.

An adult ***S. brasiliensis*** can weigh between 600 and 900 g and measure between 38 and 42 cm. Adult ***S. floridanus*** weigh 800-1000 g and measure 37-46 cm. The former is greyish brown dorsally and white or greyish white ventrally. The ears are small and rounded and the tail barely visible.

The latter has more pointed ears, is yellowish brown dorsally with a reddish spot behind the head, and is greyish white ventrally. The tail has a white underside which can be seen more clearly when the rabbit is running and the tail is lifted.

Both species are solitary and active both day and night. They dig shallow holes as resting sites, and make nests in tree trunk holes or between rocks. They feed on stems, tender buds, leaves, flowers, seeds and the bark of some trees. They breed prolifically. With a gestation period of one month, they can have 4-5 litters a year, each with 2-8 offspring. Each offspring can breed, in turn, at 3 months old. The young are born in shallow nests lined with plant material and the mother's hair.

The distribution range of ***S. brasiliensis*** is from eastern Mexico to Argentina, not including El Salvador. That of ***S. floridanus*** includes different regions from Canada to Costa Rica, Venezuela and Colombia.

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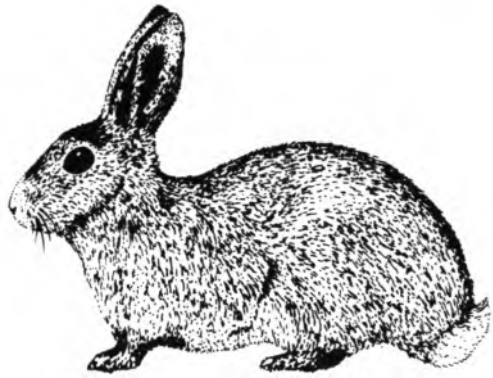
Sylvilagus spp.
(Lagomorpha: Leporidae)



Sylvilagus sp.

References: ARANDA & MARCH, 1987; HALL, 1981; MENDEZ, 1970; MORA & MOREIRA, 1984; NOWAK & PARADISO, 1983; TIMM, 1983.

3. PATHOGENS

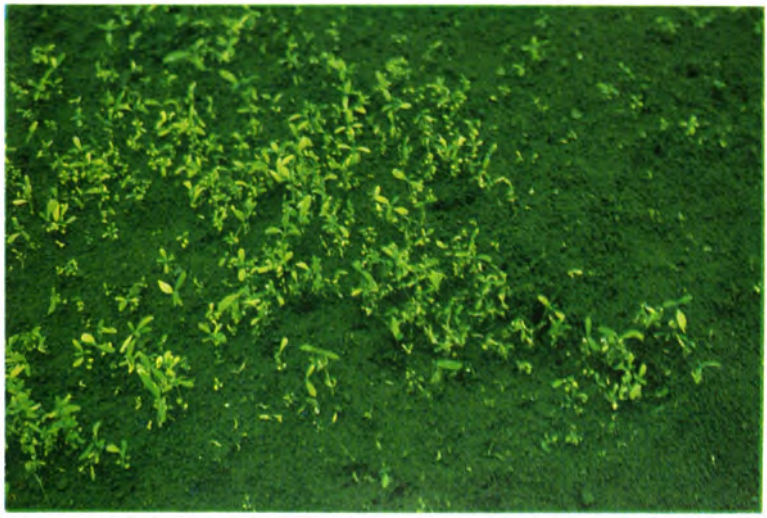
Damping off

This is caused by the attack of a complex of soil fungi and is often seen in nurseries. The symptoms include chlorosis, wilting, constriction of the stem and root rot. In most cases, it is caused by fungi such as ***Rhizoctonia solani***, ***Fusarium*** sp., ***Pythium*** sp., ***Phytophthora*** sp., ***Cylindrocladium*** sp. or ***Botrytis cinerea.***

According to the timing of the attack, damping off is classified as pre-emergent, post-emergent or late.

Pre-emergent damping off

The fungi damage the seed or kill seedlings before emergence. There is necrosis of the cotyledons and hypocotyl. The infection is difficult to diagnose since there are no visible symptoms and its presence is usually only suspected due to low percentage germination.



Pre-emergent damping off

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Post-emergent damping off

Seedlings are most susceptible to this during the first few days after emergence. The seedling is infected at the base of the stem or just slightly below, causing constriction of the stem, followed by drooping and, in one or two days, death of the seedling.

In conifers, especially ***Pinus*** spp., drooping of the seedlings is evidence of the disease. If seedlings in seed beds bend over when a hand is brushed over them, this is an indication that the disease is present. In broadleaved species, the symptoms are chlorosis and gradual wilting of the seedlings until they droop.

Infected plants can form foci in seedling beds or be mixed with healthy plants.

Post-emergent damping off

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Late damping off

This usually occurs weeks or months after emergence in seedlings which already have woody tissue in the roots.

Above ground, there is chlorosis of the leaves and wilting of the terminal bud as a result of root death. In ***Pinus*** spp. the lower needles turn a chestnut color. The rotten roots lose their consistency and the bark can easily be removed.

At this level, diagnosis is difficult since nematodes, insects, nutritional deficiencies or poor watering can induce similar symptoms above ground. For this reason, the roots must be examined to confirm a fungus attack.

Late damping off

General methods of control

Damping off can be reduced by cultural methods or chemical control. With cultural practices the aim is to avoid introduction of the pathogen or prevent unchecked growth of the disease in seedling beds. Since the disease is caused by several fungi it is necessary to know

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their specific requirements in order to provide an environment which is unfavorable to their development and favorable to the tree's development. Poor drainage, heavy soils, high sowing densities and soils with a high organic matter content all favor the appearance of damping off.

Where seedlings are started in germination beds, a substrate of river sand or a 3:1 mixture of river sand and disinfected soil is preferable, to avoid fungal contamination and give efficient drainage. The site should be roofed and well ventilated and watered by sprinkler.

The substrate can be disinfected by the application of vapor or chemicals such as methyl bromide or Vapam. A dosage equivalent to one can of methyl bromide per cubic meter of dry substrate should be applied and the soil covered for 24 hours to avoid volatilization of toxic gases. The soil should then be uncovered and left to air for 48 hours before sowing. Vapam is applied by sprinkler to 10 m^2 rows, at a dosage of 100 ml/m^2.

A recommended seedling production technique, not used in Central America, is to raise seedlings in pieces of wide mouthed plastic tubes. This keeps the seedlings raised above the level of splashing from the soil and significantly improves drainage.

Sowing in plastic bags has more to recommend it than seedling beds. The soil should be disinfected and mixed with, in decreasing order, vermiculite, rice husks and a sandy subsoil. This should be fumigated to eliminate pathogens and other pests such as insect larvae, nematodes and weeds should be removed.

In the case of eucalypts, the leaves should be removed when the seedlings are 4 to 7 cm high, to improve air circulation. Waiting until the plant grows and its leaves completely cover the nursery area is not recommended from a silvicultural or phytopathological point of view.

All plant material and leaf litter on the soil surface, along with the older, lower leaves on the stem of the plant, should be removed since they increase the risks of fungal attack. This requires full time vigilance in the nursery.

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Damping off

Sowing density is extremely important since it is one of the factors that affects soil humidity and aeration between plants. The greater the density, the greater the soil humidity and relative humidity of the air, hence the greater the risk of pathogen attack. Furthermore, the use of high sowing densities limits the possibilities of control and complicates the elimination of residues from the soil.

The principal pathogens involved in damping off are briefly described below, along with some aspects related to their epidemiology.

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Damping off

Damping off: sequence of attack and symptoms that may occur in nurseries.

Rhizoctonia solani

This fungus has a wide distribution all over the world, both in cultivated and uncultivated soils. It can act as a saprophyte or be a plant pathogen. Morphologically it is characterized by having a brown, filamentous mycelium (in artificial medium) which branches at right angles. The septa are slightly constricted close to where they branch.

Spores are not produced either in natural conditions or culture medium, so that the characteristics of the mycelium are fundamental for identification. Sclerotia from 0.2 to 2 mm diameter are produced and these constitute the chief means of generation.

During the development of the plant, the hyphae surround the host tissue and subsequently penetrate it. The mycelium advances inter and intracellularly and kills the plant by deeply ringing the stem, normally at soil level. Cultural practices, watering or rainfall produce movement of soil particles which fragment the mycelium and transport pieces of hyphae with sclerotia. The mycelia or sclerotia survive on decomposing tissues.

R. solani attack can occur in pre-emergent, post-emergent or late damping off. Its hosts include some species of ***Eucalyptus***, ***Pinus***, ***Leucaena leucocephala***, ***Caesalpinia peltoforoides*** and ***Acacia mangium***.

Pre-emergent attack manifests itself as failure of the seedling to emerge. In post-emergent attack, a ring appears at the base of the stem and the plant subsequently falls over. In more developed plants there is no falling over, only ringing of the stem and wilting of the foliage, followed by the seedling's death. The ringing is clearly visible to the naked eye, especially in older seedlings, being darkly colored, close to the base of the stem. The disease spreads in foci.

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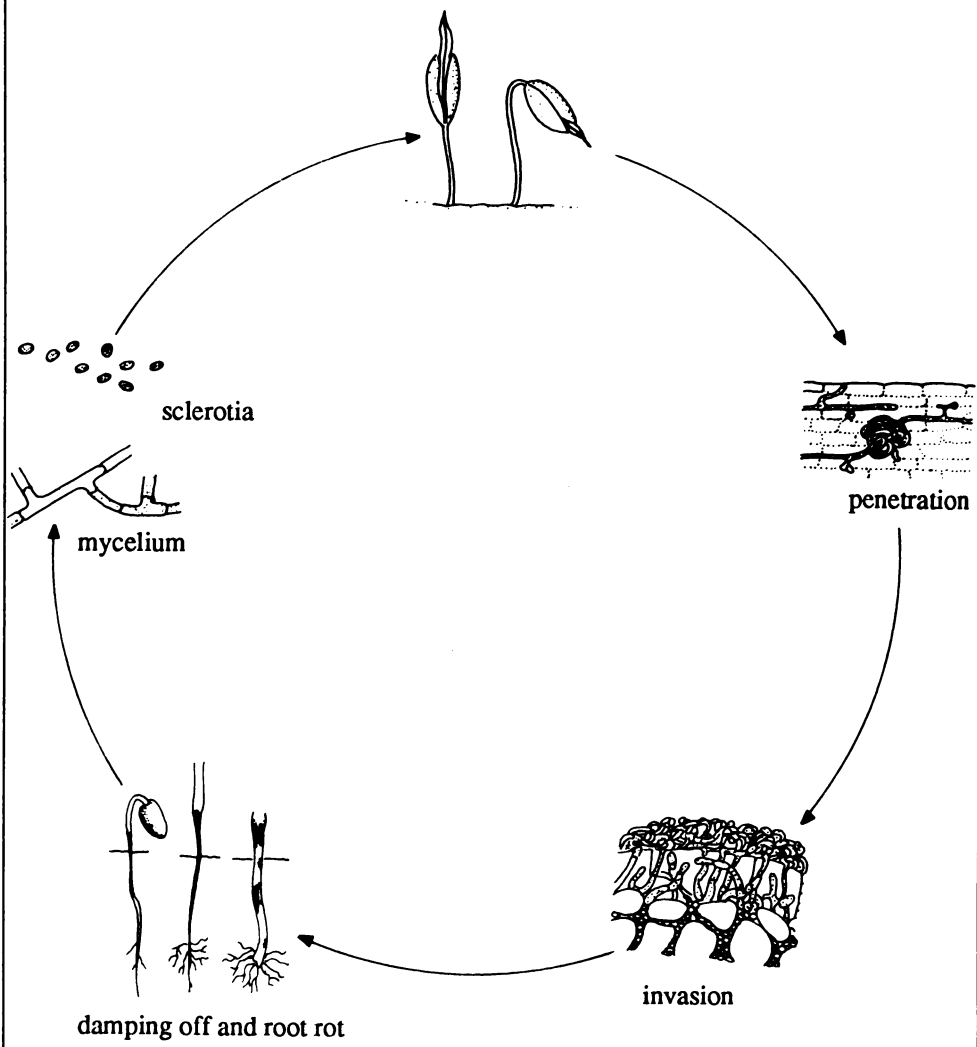
Rhizoctonia solani



Damping off cycle caused by ***Rhizoctonia solani***

References: DEMUNER *et al.*, 1987; FERREIRA *et al.*, 1988; LOPEZ, 1986; NAPIER, 1982; OGOSHI, 1987; OROZCO, 1984; TAHA *et al.*, 1987; VASQUEZ, 1981.

Fusarium spp.

This genus is a facultative parasite which normally lives in the soil. Amongst those species which act as pathogens in nurseries, the most commonly encountered are: ***F. centricosum***, ***F. moniliforme***, ***F. oxysporum*** and ***F. solani***. This fungus is distributed all over the world with a wide range of hosts including: ***Anthocephalus cadamba***, ***Casuarina equisetifolia***, ***Cupressus lusitanica***, ***Eucalyptus*** spp., ***Leucaena leucocephala***, ***Alnus acuminata***, ***Gliricidia sepium***, ***Bombacopsis quinatum*** and ***Tectona grandis***.

The fungus produces a white, downy growth on the affected tissues. This is made up of septate mycelia with chlamydospores and numerous conidia (both macro and microconidia). In culture media the colonies are white. Some, depending on species, produce a reddish or purple pigment under the colony. The optimum temperature for development is between 25 and 30°C.

Fusarium spp. symptoms are distinct from other pathogens in that a reddish coloration can be seen in the damaged tissue or a darkening of the internal stem tissue occurs a few centimeters above the lesion site.

Mycelia or chlamydospores survive on decomposing tissue.

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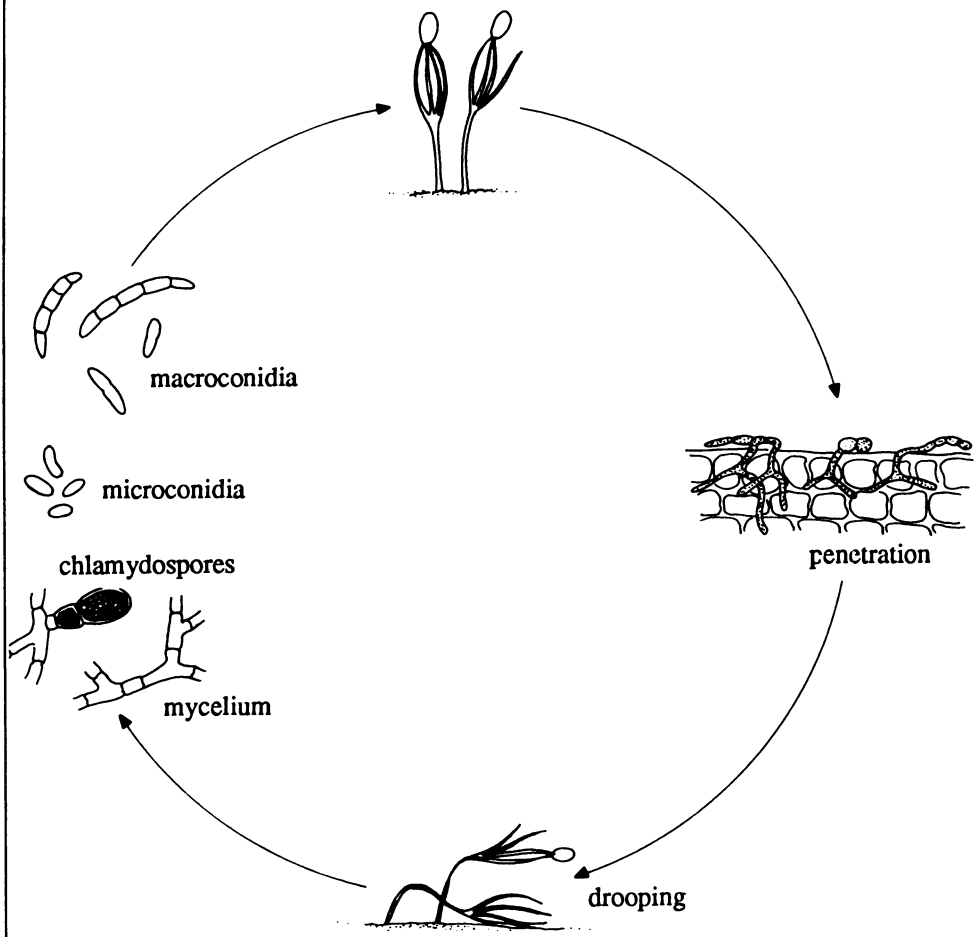
Fusarium spp.



Damping off cycle caused by ***Fusarium*** spp.

References: FERREIRA, 1989; LOPEZ, 1986; MICHAIL & EL-SAYED, 1986; NAPIER, 1982; TAHA ***et al***, 1987.

Pythium spp.

This fungus lives in the soil and acts as a facultative parasite. It lives saprophytically and can occasionally attack plants, especially during the first few weeks of growth when they develop under high humidity. It is associated with ***Rhizoctonia*** sp. and ***Fusarium*** spp. in damping off and seems to be the most important agent in pre- and post-emergent phases of the disease.

The fungus produces a white, filamentous mycelium on the infected material. This grows rapidly and forms many branches. Infection occurs from mycelia originating on plant residues. These spread internally and produce sporangia which later liberate spores into the soil. When temperatures are higher than 18°C, the sporangia germinate and form new hyphae. At temperatures between 10 and 18°C, the sporangium liberates zoospores which encyst. After a latent period the zoospores germinate to reinitiate the process of infection.

At the start of the infection, depending on humidity and sowing depth, symptoms may be barely perceptible below soil level. The mycelia destroy the cell wall and consume the cell contents, causing necrosis in the infected area. In seedlings, invasion and death are rapid. In more developed plants, the lesion grows for a time under ground level until it limits water transport and causes the death of the plant. In more mature plants with lignified tissues and thicker cell walls, the fungus is limited to the infection site and cannot form a large lesion.

The main hosts are ***Eucalyptus*** spp., ***Pinus*** spp. and ***Caesalpinia peltoforoides***.

References: FERREIRA, 1989; LOPEZ, 1986; SHARMA *et al.*, 1984, 1985.

Phytophthora spp.

Several species of ***Phytophthora*** cause root rot. In seedlings, death can occur in a few days or take several weeks. In adult plants, root rot may be slow or fast depending on the inoculum and environmental conditions. Attack by the pathogen causes complete destruction of the root system, causing the death of the whole plant. The most affected genus is ***Pinus***.

The fungus exists in the form of oospores, chlamydospores or mycelia in infected roots or the soil. The mycelia can produce sporangia which, like the oospores, can germinate to reinfect. Like ***Pythium*** spp., between 10 and 12°C ***Phytophthora*** spp. liberate zoospores from the sporangia. Once these germinate they can produce a new infection. Attacks are most severe in nurseries where there is high humidity and temperatures between 15 and 23°C.

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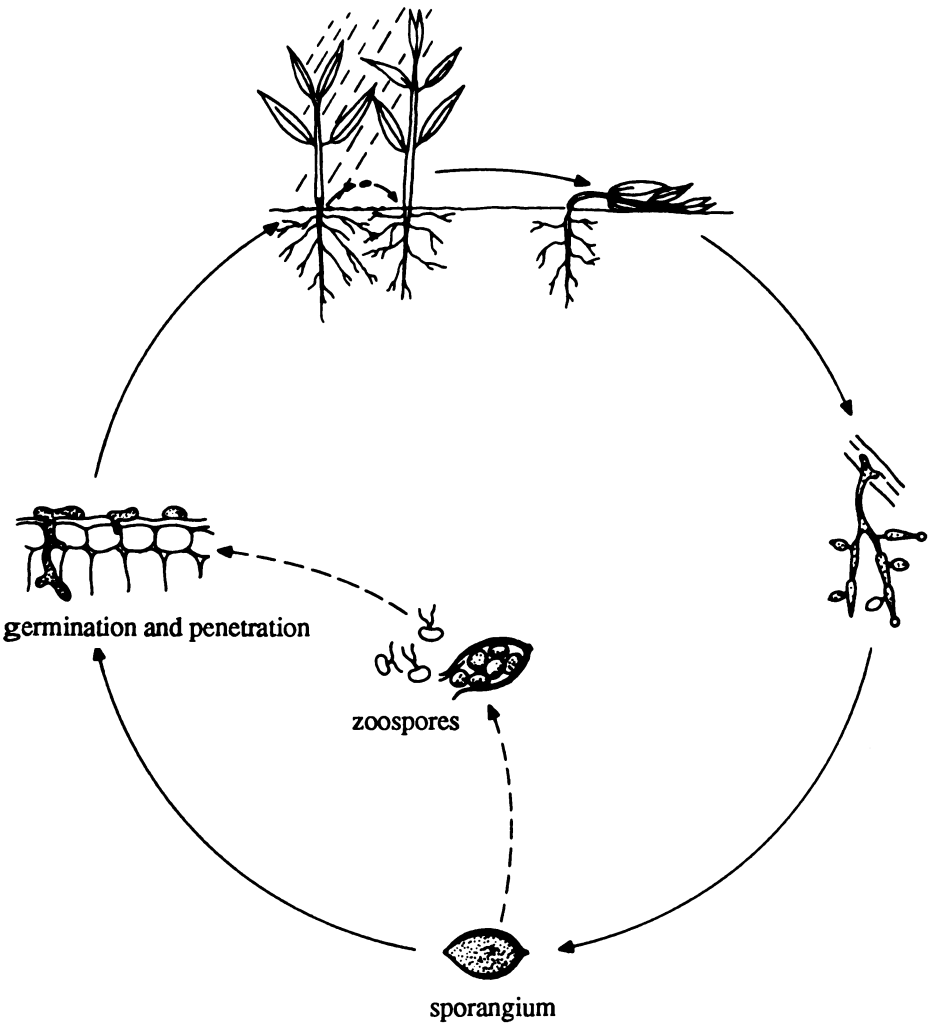
Phytophthora spp.



Asexual life cycle of ***Phytophthora*** spp.

References: AGRIOS, 1979; DAVIDSON & TAY, 1987; HAMM, 1984.

Cylindrocladium spp.

This pathogen is very common in eucalypt nurseries since this species is it main host. It is a facultative pathogen which survives in soil as chlamydospores or microsclerotia on decomposing organic matter. Various species have been found to cause damping off in ***Eucalyptus*** sp., such as: ***C. quinqueseptatum***, ***C. ilicicola***, ***C. parvum***, ***C. clavatum***, ***C. camelliae*** and ***C. scoparium***. Of these, the last is the most common.

The fungus grows well in PDA medium at temperatures between 25 and 30°C inclusive. The colonies are brown and cottony and can grow up to 6 cm in diameter after only one week's incubation.

The inoculum spreads via soil particles which rain splashes or water run off carry to neighboring plants. The resistant structures germinate or the mycelium grows, infecting seedlings in the area of the base of the stem. Both hyphae and germ tubes of the conidia can directly penetrate the tissues, although the process is speeded up when there is a wound or opening.

Cylindrocladium spp. not only infect root tissue but also the stem and foliage, in the pre-emergent phase through to adult plants. Its distribution is almost worldwide.

References: FERREIRA, 1989; FERREIRA ***et al.***, 1988; SHARMA ***et al.***, 1984, 1985; TAHA ***et al.***, 1987.

Botrytis cinerea

This is a saprophytic pathogen with a wide range of hosts. It survives in leaves or stems in the soil and on these substrates produces hyphae, conidia and sclerotia. Under conditions of high temperature and humidity the sclerotia germinate producing hyphae which infect the tissues and a great number of conidia which are dispersed by the wind. Under favorable conditions, the conidia germinate and colonize new tissue, either in the same seedling or in neighbors.

In the case of ***Eucalyptus*** spp. the attack is late. It is probable that the conidia reach the foliage of the seedlings from sources of inoculum with the help of the wind. They are then washed off by the rain or watering and infect the host or settle and grow saprophytically on fallen leaves to produce secondary inoculum.

In the nursery, fallen leaves covered with grey or brown secondary mycelia are an indication of attack by the fungus, and constitute an important source of inoculum.

Symptoms may be seen in the aerial part of the plant, in buds and leaves at different heights on the stem. In all cases the lesion initially appears black and moist. It later causes death of the tissues.

The disease has been found on ***Eucalyptus*** spp. and ***Bombacopsis quinatum***.

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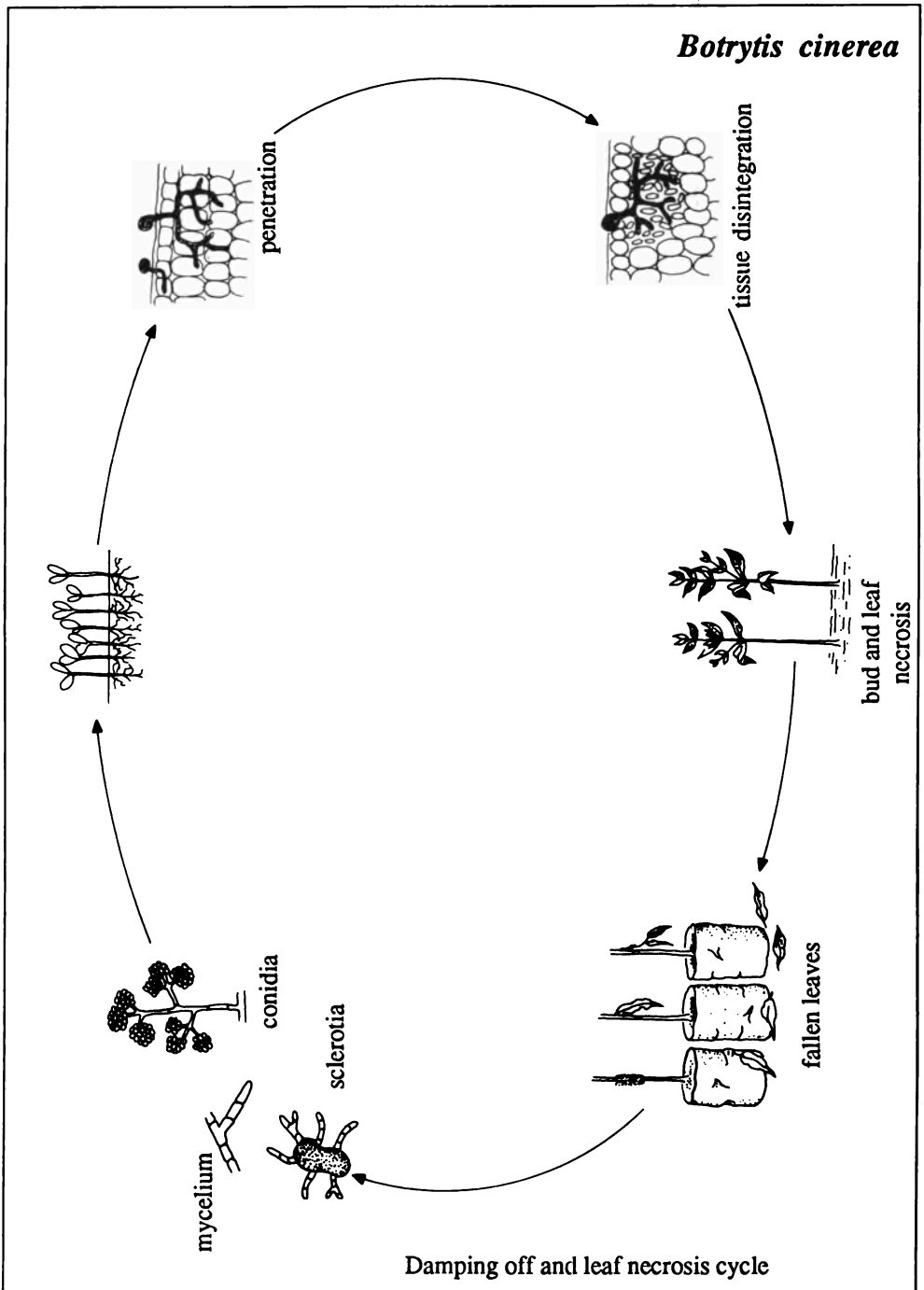


Damping off and leaf necrosis cycle

References: AGRIOS, 1979; FERREIRA, 1989.

Asperisporium sequoiae

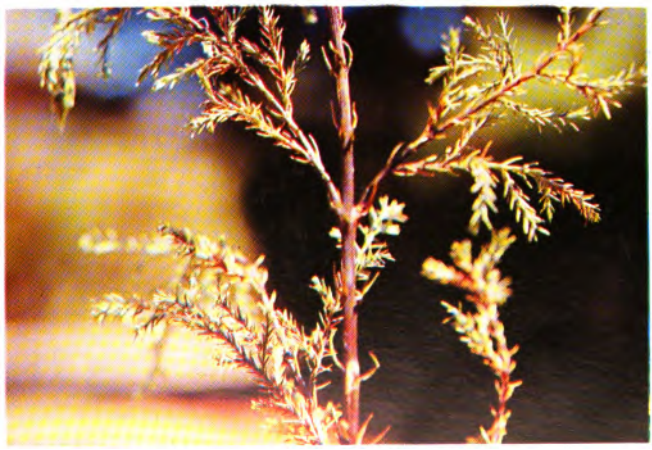
Asperisporium (syn. ***Cercospora***) ***sequoiae*** is an uncommon pathogen in Central America. To date, it has only been found in Guatemala.

It has dark conidiophores which are grouped on stromata. The conidia are needle shaped, cylindrical and hyaline. The majority have five or six septa. In PDA medium they form greyish colonies, less than 2 cm in diameter. Sporulation is greatly reduced after two weeks incubation.

Symptoms appear at the base of the crown where the needles take on a dark reddish color. At the beginning of the disease, there is no appreciable needle fall, but this is noticeable as the infection progresses. The disease is located in the periphery of the tree, in the terminal part of the branches.

The pathogen attacks stages in the nursery causing severe needle blight. The foliage becomes grey colored and fruiting bodies of the fungus can be seen on affected needles. Sporulation is more noticeable and abundant on young tissues.

The hosts are ***Cupressus lusitanica***, ***Sequoia gigantea*** and ***Thuja occidentalis***.



Cypress needle blight

References: FERREIRA, 1989; HODGES, 1989; SUTTON & HODGES, 1990.

Cercospora rangita

This disease is little known in Central America. It has mainly been seen in nurseries or in plants too mature for transplanting. In countries where the disease has been described, mention is made only that it is found in field conditions on adult ***Gmelina arborea.***

Identification of the real causal agent is still unclear. In India, ***Corynespora rangita*** is mentioned, whilst in Brazil ***Pseudocercospora*** (syn. ***Cercospora***) ***rangita*** is named as the pathogen responsible for the disease. On the basis of microscopic observations carried out in Costa Rica, the reproductive structures appear very similar to those of ***Cercospora*** genus although the conidia are slightly different from the typical generic pattern. They certainly do not resemble those of the genus ***Corynespora.***

Symptoms are quite characteristic and mainly appear in adult leaves. The lesions are dark brown, irregularly circular, randomly distributed and up to 1 cm in diameter. As they develop, they turn light grey in the center with a barely visible chlorotic halo. Adjacent lesions may join up.

Gmelina leaf spot

References: FERREIRA, 1989; SHARMA ***et al.***, 1985.

Corticium salmonicolor

This pathogen causes frequent damage in a wide range of hosts in the humid tropics. It is found in eucalypt plantations in regions with annual rainfall over 2,000 mm.

It is easily isolated in PDA culture medium. The mycelium is whitish, becoming pink with age. The pink coloration appears earlier when the fungus grows exposed to light at temperatures between 24 and 27°C.

The pathogen attacks trees over two years old, although in humid areas, symptoms are found in younger trees. In ***Eucalyptus*** spp., susceptibility is greatest in trees 2-4 years old and the attack is located at 1.5 or 2.0 m height. The disease is characterized by a pink growth over a canker which forms at the point of infection on the stem. The infection may occur at any point on the main stem or branches and causes the death of the internal tissues and the subsequent appearance of the canker. The mycelium grows on the bark and may encircle the stem completely. When this happens, the tree dies in the region above the canker while below it there may be resprouting. During the dry season the canker exhibits longitudinal cracking.

Given the humidity requirements of the fungus, ***Eucalyptus*** spp. should not be established in areas with annual precipitation higher than 2,000 mm. If there are no economic resources to fight the disease, the infected tissue should be removed by pruning. Plantations with a high value may be protected by the application of copper based fungicides during the wet season or by painting the affected areas with a mixture of copper and lime.

Corticium sp. attack has been observed in ***Eucalyptus*** spp., ***Gmelina arborea*** and ***Tectona grandis***.

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Corticium salmonicolor

Pink disease

References: BAKSHI *et al.*, 1978; FERREIRA, 1989; SEGURA, 1970a; SETH *et al.*, 1978; SHARMA *et al.*, 1978.

Pine Stem Rust
Cronartium sp.

This disease is widely distributed in Europe, Asia and the United States, especially in areas with a temperate climate. It is not, as yet, an important disease in Central America, only being reported in Honduras and Guatemala. However, it should be considered as a potential problem for the region. Pine Stem Rust shows many different symptoms and may be caused by different species of ***Cronartium***. Symptoms observed in Central America seem to correspond to those caused by ***C. quercuum***, also known as ***C. cerebrum***.

The fungus causes the growth of round galls on the branches. Although it can attack nursery seedlings, causing their death, the pathogen is more frequent and evident in adult trees where it causes deformation of the trunk and retards growth. Galls produced by other species of ***Cronartium*** in cones and branches may be attacked by the larvae of the pyralid lepidopteran ***Dioryctria*** sp. The only known hosts belong to the genus ***Pinus***.

Cronartium sp. gall on ***Pinus*** sp.

References: AGRIOS, 1979; BOYCE, 1961; HIRATSUKA, 1987.

Eucalypt Canker
Cryphonectria cubensis

In many countries of tropical America, this is the main disease of eucalypt plantations. In Central America, the incidence has not yet reached high levels and the disease has only been found in the Atlantic zone of Costa Rica where climatic conditions favor the development of the fungus. Although there are no accurate loss data, significant damage affecting up to 57% of trees in plantations has been reported.

The causal agent, ***Cryphonectria*** (syn. ***Diaporthe***) ***cubensis***, is an Ascomycete which produces pycnidia superficially or slightly sunken into the bark. To the naked eye, these appear as small black spots on the damaged tissue. They are pear shaped and contain hyaline, oval, unicellular conidia. In the field, the perfect or sexual stage can be found in the form of tiny hair-like perithecia which extend from the surface. Each ascus contains eight hyaline, bicellular, cylindrical, unconstricted ascospores with rounded, straight or curved ends. ***Cryphonectria*** sp. grows easily in PDA culture medium where it forms radial, orange colonies. These can invade the whole medium (90 mm diameter) in just six days at temperatures between 28 and 30°C. At temperatures below 25°C or above 35°C, growth is slower and at 10°C or 40°C growth stops.

This disease only appears in plantations. Symptoms start to appear in the fifth month after planting and the disease lasts up to one and a half years. Plant death is caused by constriction of the stem. In older trees, new bark forms over the necrotic area so that fissures caused by pressure on the old bark can be seen along with laceration of the trunk. In these areas a large number of black spots can be seen on the tissue, even though the typical canker is not present.

Characteristic of the disease is a depression in the bark, normally close to the base of the trunk, surrounded by a narrow wound callus. This area is darker and contrasts with the healthy tissue. As the callus develops, the skin dries, cracks and falls off leaving the wood exposed. The pycnidia or perithecia of the fungus grow on the wound. The size of the canker depends on the host's susceptibility and environmental conditions. Although symptoms are normally found at the base of the stem, they can also appear higher up and in the axils of dead or broken branches.

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In adult trees, the disease causes loss of resistance in the trunk and breaks can occur in the area of the canker. It also causes reduction in growth and the number and vigor of shoots. Trees which survive damage lose their competitive potential.

Temperature and humidity are the most important factors in the growth of the fungus. Severe attacks are seen in areas with annual rainfall higher than 1,200 m and temperatures between 20 and 32°C. Wind, insects and rain spread the inoculum to healthy trees where it reproduces or starts a secondary cycle. The fungus can survive as a saprophyte on alternative hosts.

All the hosts identified belong to the genus ***Eucalyptus***.

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Cryphonectria cubensis

Eucalypt canker

References: BARNARD *et al.*, 1987; BOERBOOM & MASS, 1970; FERREIRA, 1989; HODGES *et al.*, 1979; SHARMA *et al.*, 1985.

Eucalypt Leaf Spot
Cylindrocladium spp.

This leaf pathogen is commonly found in the field where it attacks several species of ***Eucalyptus*** in tropical countries. It is distributed throughout Central America, although not at epidemic levels. It attacks trees of all ages, producing extreme defoliation during the seasons of high rainfall.

The species ***C. crotalariae***, ***C. ilicicola*** and ***C. scoparium*** have been reported from ***Eucalyptus*** sp. leaves. They have long, thin, hyaline conidia with from one to three septa. The conidiophores have an oval or globular terminal vesicle. In culture medium, the colony is light brown and reaches optimum growth at temperatures between 26 and 29°C.

Infected trees have light brown leaf spots up to 1.5 cm in diameter. These start at the margins and the apex of the leaf and move towards the centre and base. There is generally only one lesion per leaf, but sometimes up to three may be seen. In most ***Eucalyptus*** species, the lesion has a wide chlorotic halo.

The fungus survives as chlamydospores or microsclerotia in fallen leaves. At the beginning of the rainy season these produce mycelia and later conidia, which are spread to foliage by splashes of rain or insects. The fungus infects the leaves and produces new conidia which spread to other leaves and plants. The disease is not found in nurseries. It has not been necessary to implement control measures in the field since the disease has not reached epidemic levels in areas or seasons of moderate rainfall. Furthermore the plant shows good recovery even after severe defoliation. The disease tends to be located in the lower third of the tree, where the plant tends to shed its leaves in any case. This favors low incidence since there is greater aeration, less humidity and the susceptible tissue is higher up. The severity of the infection is related to the rapid growth of the tree during its first years. If the treetop manages to grow higher than the height where the fungus is found, it will escape infection.

Hosts include ***E. acmenioides***, ***E. alba***, ***E. camaldulensis***, ***E. citriodora***, ***E. cloezima***, ***E. dunni***, ***E. grandis***, ***E. maideni***, ***E. microcorys***, ***E. paniculata***, ***E. pellita***, ***E. rudis***, ***E. saligna***, ***E. torelliana*** and ***E. urophylla***.

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Cylindrocladium spp.

Eucalypt leaf spot

References: ALFENAS & FERREIRA, 1979; FERREIRA, 1989; SEGURA, 1970b; SHARMA *et al.*, 1985.

Dothistroma Needle Blight

Dothistroma septospora

This is probably one of the most important pathogens of pine plantations and is certainly one of the most studied. It has worldwide distribution with high incidence in Africa, New Zealand, Chile, Brazil and the United States. In Central America references to the disease go back to 1978.

D. septospora (syn. ***D. pini***), which has ***Scirrhia pini*** as its perfect phase, produces conidia in needle shaped, long, hyaline stromata with one or three septa. In culture medium the colonies are black with a smooth surface. After 30 days incubation they barely reach 1 cm in diameter.

In the nursery the disease appears at the end of development. In the field, it appears when trees are six to eight months old. The disease starts in needles at the base of the trunk and ascends to the top and periphery of the tree. Lesions may appear in any part of the needle. These are yellow at first, later turning into reddish brown or yellow rings, a few millimeters thick. One needle may have several lesions which cause death in tissues distal to the infection point. Severely affected trees appear reddish, with the branches covered in dead needles. Eventually these drop and the tree shows new, healthy foliage at the ends of the branches and in new shoots.

As a consequence of the attack, the tree fails to achieve its full potential height and diameter. Occasionally the pathogen causes the tree's death, but this is uncommon.

The disease is introduced to the field from infected nursery plants. Frequent rain and temperatures between 12 and 18°C encourage sporulation. The fungus can reach epidemic levels with wind and rain spreading the inoculum.

Reduction in growth is not noticeable until two years after the disease appears and is more pronounced when more than 25% of the foliage is affected. If the attack affects 80% or more of the needles, the tree stops growing or dies. Most effective control of ***Dothistroma septospora*** comes from strict health measures in nurseries, so as to avoid introduction to the field where control is more difficult. Some

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species show partial resistance to the disease and there are some resistant plants within the same species, depending on their place of origin. The recommended control measure to reduce visible signs of attack is the application of fungicide before 25% of needles are affected. Several different types of products have been tested and the most commonly used and most efficient are copper based fungicides. In cases of more severe damage (25-40% needles affected) pruning is also recommended to remove diseased tissue.

Hosts of the disease are: ***Pinus*** spp., ***Larix decidua***, ***Picea sitchensis*** and ***Pseudotsuga menziesii***.

Dothistroma needle blight

References: ARAYA, 1988; FERREIRA, 1989; FIGUEREIDO & NAMETAKA, 1969; FORD, 1982; GIBSON, 1972, 1974; HELDRIDGE & DOWDEN, 1980; PETERSON, 1984; ROUX, 1984.

Cypress Rust
Pestalotia sp.

This disease attacks cypress trees at all developmental stages, from seedling to mature tree. In recent years it has become very important since extensive areas have been reforested with cypress. The disease is found all over Central America and tends to be more severe during the dry season.

Pestalotia was previously known as ***Pestalozzia*** and is now also known as ***Pestalotiopsis***. Some researchers consider it a weak parasite with several hosts which takes advantage of conditions of stress to attack. Others refer to it as a saprophyte which occasionally behaves parasitically. The conidia are produced on acervuli and are straight or slightly curved with a pointed end, have two or four dark, central cells and hyaline cells at the ends. At one end there are three simple, hyaline appendages. In culture medium there is compact, white cottony mycelial growth which, when mature, produces masses of conidia in the acervuli. These appear as shiny black spots rather like oil drops.

Damage starts as small brown spots surrounded by slightly dark chlorotic tissue. The necrosis advances and soon covers the whole leaf. Affected leaves die but stay on the tree. The acervuli, which appear as dark powdery spots, cover the leaf. Affected areas appear dark red colored like rust. Damage extends to the central part of the tree. The attack is less in the lateral tips and the apex. Diseased trees rarely die, but lose vigor and are more susceptible to other damage.

Severe attacks have been seen in plantations on poor soils where the tree has insufficient macroelements and boron and on compacted soils. Both in nurseries and plantations, the attack is worse during the dry season and improves slightly in the rainy season.

Hosts are: ***Cupressus lusitanica***, ***Eucalyptus*** spp., ***Gliricidia sepium***, ***Casuarina equisetifolia*** and ***Acacia mangium***.

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Pestalotia sp.

Cypress rust

References: ARAYA *et al.*, 1988; ARAYA & GUILLEN, 1984; ARGUEDAS, 1986; FERREIRA, 1989; OROZCO, 1984; TUSET & HINAREJOS, 1985.

Cypress Canker
Seiridium cardinale

This disease is not as important in Central America as it is in Europe and other American countries, where it attacks several species of ***Cupressus***. It was first noticed in Guatemala in 1989, where it killed 13-15 year old ***C. lusitanica*** trees. In countries where the disease is important, it attacks all stages from seedlings to adults, some even 40 years old.

The causal agent, ***Seiridium*** (syn. ***Coryneum***) ***cardinale***, produces conidia in acervuli. They are dark and fusiform with hyaline ends and dark central cells. They are located in the apex of the conidiophore and have four or five septa. In PDA medium, the colonies can reach a mean diameter of 5.5 cm after 10 days incubation at 22-24°C. The colonies are olive green-grey in the centre and lighter at the edges. The acervuli can be seen after 15 days incubation in diffuse light at 16-18°C.

The pathogen attacks the trunk and branches of the tree. The first symptom is the appearance of resin secreted through fissures in the bark. Necrotic tissue is visible under these cracks and this later extends longitudinally, forming a canker. In young branches, the bark is sunken and reddish brown in color, later cracking in longitudinal fissures which do not affect the wood. The canker later grows to encircle the whole branch and the terminal part gradually changes color from chlorotic to reddish before dying. The necrosis can descend to the trunk and cause the death of the tree.

The fungus can survive for over three years as a saprophyte in dead branches. The acervuli liberate conidia which infect new tissue. Environmental conditions favoring the development of the disease are rainfall and alternating periods of high humidity. Temperatures of around 25°C are most favorable for germination and penetration of the conidia, although infection has been observed in temperatures from 5 to 30°C.

Burning the affected tissue or plants to reduce the inoculum is necessary to control the disease. Several fungicides have been tried but none has given positive results. In any case this form of control would be impractical in Central American plantations. Some species of ***Cupressus*** have shown various levels of tolerance. Another of its hosts is ***Thuja*** spp.

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Seiridium cardinale

Cypress canker

References: HODGES, 1989; RADDI & PANCONESI, 1981; VALDIVIESO & LUISI, 1987; VALDIVIESO *et al.*, 1988.

(Saquisaqui Ringing)

This disease is frequently encountered in nurseries and causes important losses especially in hot areas and during the dry season.

The initial symptoms are yellow spots at the base of the stem, later turning orange or red, and a slight hollowing of the affected area. In more advanced stages, the red area darkens and the bark cracks. The hollowing is more pronounced and finally encircles the stem, hampering growth and sometimes causing plant death. Seedlings taken out to the field with early symptoms manage to maintain a stable condition during the rainy season but the disease progresses in the next dry season. The tree dies in one or two years depending on the stage of the lesion. Dead trees easily break at the site of the ringing, or about 10 cm higher, and can then produce healthy regrowth.

High soil temperature has repeatedly been mentioned as the main cause of the disease, as demonstrated by the fact that damage occurs in hot weather and during the dry season. The fungi ***Macrophomina phaseolina*** and ***Verticillium*** sp., two soil dwelling pathogens, have been found in the tissue of the ringed area, but artificial inoculations of these have not produced disease symptoms. It is likely that they are secondary pathogens which take advantage of the tree being under stress, but do not cause the main damage.

Although specific research has yet to be carried out, it seems that exposed soils, high planting densities, high temperature and sowing late in the rainy season are all factors which favor the development of the disease.

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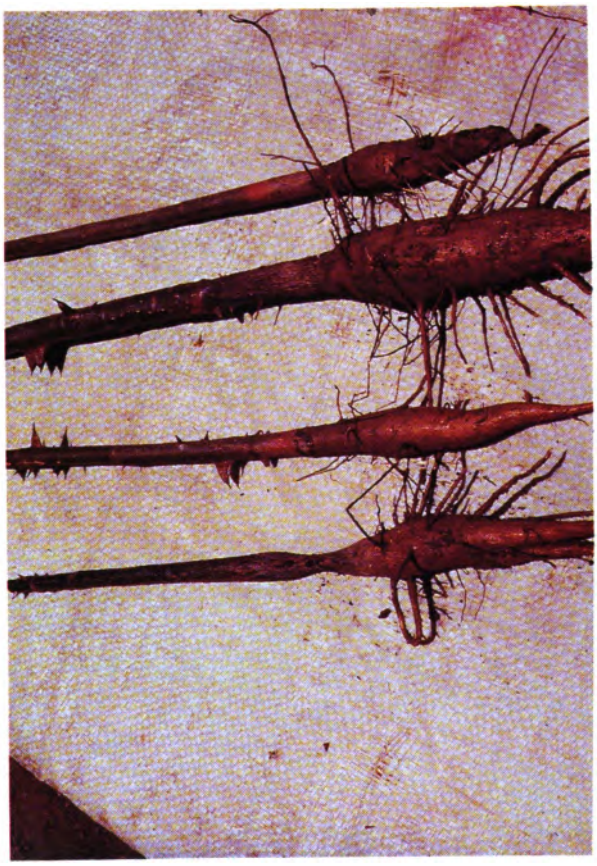

Saquisaqui Ringing

(Eucalypt Gummosis)

Gummosis, like "Black Stem", is a common physiological condition of eucalypts. It begins with the secretion of a resinous substance from several points on the trunk. This resin is dark, glassy and mucilaginous. When it makes contact with the air, it dries and crystalizes, sticking to the bark at the point where it emerged. At these same sites there are small longitudinal openings which may or may not be associated with bulging or hollowing of the bark.

Gummosis is the tree's response to factors such as mechanical damage, cutting with tools, strangulation, insect or disease damage, frost, fire, drought, strong winds and other adverse climatic conditions. It should not be confused with the gummosis produced by certain pathogens.

Normally, gummosis does not kill the tree. Its frequent occurrence indicates adverse conditions in the plantation which, themselves, may affect growth.

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(Eucalypt Gummosis)

Eucalypt gummosis

References: FERREIRA, 1989.

(Eucalypt "Black Stem")

This occurs in some adult eucalypts. It has been seen in Honduras, but probably exists in other Central American countries too.

A black crust or scab appears on the trunk and moves downward, as a result of resin exuding at several points. As the resin appears, rain washes it down the trunk to form a film. This dries and oxidizes to a dark color. "Black Stem" is seen in trees over four years old and does not normally result in the death of the tree.

The symptom is the plants response to adverse environmental conditions such as lack of water or micronutrients. ***E. grandis*** has been noted as the species most susceptible to damage.

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(Eucalypt "Black Stem")

Eucalypt "Black Stem"

References: FERREIRA, 1989.

(Eucalypt Bud Blight)

This condition, of abiotic origin, is not very widespread. It was first mentioned in Brazil in 1974 and seen in the Atlantic zone of Costa Rica in 1987. Because of this, there is little information on its behavior in Central America. It attacks several species of ***Eucalyptus*** in the first five years of development.

The most frequent symptom is the death of internal tissues in the terminal bud, in branches and new shoots. Damage appears at first as a slight blight of the youngest tissue, advancing to affect other tissues, which turn black and finally wither. The blight descends to the axil of the branch where it stops. Cankers or exudation may occur here, although the latter reaction has not been observed in Costa Rica. The necrotic tissue dries and hardens making it liable to break easily. Below the axil, the tree starts to put out healthy regrowth.

Fungi such as ***Botryosphaeria ribis***, ***Colletotrichum gloeosporioides***, ***Coniella fragariae***, ***Pestalotia*** sp. and ***Phoma*** sp. have been isolated from diseased tissue. These are almost certainly not primary pathogens since they are normally weak, secondary pathogens which behave opportunistically on weakened trees. Furthermore, artificial inoculation with these fungi fails to reproduce symptoms of the disease.

The disease symptoms seem similar to those of "Rio Dulce disease" identified in Brazil and associated with problems of soils liable to flooding or a high water table. However, other edaphic or climatic factors may have a role in the appearance of the disease and these must be investigated.

Control includes the use of eucalypt species which show tolerance to damage, especially in the upper third of the tree. Another important factor is site selection, choosing well drained soils and areas well suited for the growth of affected eucalypt species.

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(Eucalypt Bud Blight)

Eucalypt bud blight

References: DIANESE *et al.*, 1984a, 1984b; FERREIRA, 1989.

REFERENCES

ALFENAS, A. C.; FERREIRA, F. A. 1979. A mancha da folha do eucalipto no Brasil causada por tres espécies de ***Cylindrocladium***; uma revisâo da descriçâo da doença.Revista Arvore (Bra.) 3(1): 47-56.

ANDREWS, K. L.; CABALLERO, R. 1989. Guía para el estudio de órdenes y familias de insectos de Centroamérica. 4 ed. El Zamorano, Hond., Escuela Agrícola Panamericana. 179 p.

ARANDA, M.; MARCH, I. 1987. Guía de los mamíferos silvestres de Chiapas. México, INIREB-PSTC. 149 p.

ARAYA, C. M. 1987. Prevención y combate de enfermedades que afectan viveros forestales. **In** Curso Entom. y Patol. Forestal Tropical. (1., 1987, Campeche, Méx.) 17 p.

ARAYA, C. M. 1988. ***Dothistroma pini***: un problema potencial en Costa Rica. **In** Compendio sobre experiencias en la biología y comportamiento de plagas y enfermedades forestales en Costa Rica. Cartago, C.R., Inst. Tecnol. de Costa Rica. p. 75-82.

ARAYA, C. M.; ARGUEDAS, M.; SCORZA, F. 1988. Enfermedades de árboles en Costa Rica. **In** Compendio sobre experiencias en la biología y comportamiento de plagas y enfermedades forestales en Costa Rica. Cartago, C.R., Inst. Tecnol. de Costa Rica. p. 45-63.

ARAYA, E.; GUILLEN, A. L. 1984. Evaluación del daño causado por ***Pestalotia*** sp. en ***Cupressus lusitanica*** Mill. Práctica de especialidad. Cartago, C.R., Inst. Tecnol. de Costa Rica. 41 p.

ARGUEDAS, M. 1986. Estudios básicos sobre el herrumbre del follaje del ciprés. **In** Compendio sobre experiencias en la biología y comportamiento de plagas y enfermedades en Costa Rica. Cartago, C.R., Inst. Tecnol. de Costa Rica. p. 64-74.

ARGUEDAS, M; SCORZA, F. 1988. Insectos asociados con el jaúl: plagas reales y potenciales. **In** Compendio sobre experiencias en la biología y comportamiento de plagas y enfermedades forestales en Costa Rica. Cartago C.R., Inst. Tecnol. de Costa Rica. p. 23-32.

BARNARD, E. L.; GEARY, T.; ENGLISH, J. T.; GILLY, S.P. 1987. Basal cankers and coppice failure of ***Eucalyptus grandis*** in Florida. Plant Disease 71 (EE.UU.) (4) : 358-361.

BECKER, V. O. 1976. Microlepidópteros asociados con ***Carapa***, ***Cedrela*** y ***Swietenia*** en Costa Rica. **In** Studies on the shootborer ***Hypsipyla grandella*** (Zeller). Lep., Pyrali- dae. Ed. J. L. Whitmore. IICA Misc. Publ. No. 101. V.Z., p. 75-101.

BOERBOOM, J. H. A.; MAAS, P. W. 1970. Canker of ***Eucalyptus grandis*** and ***E. saligna*** in Surinam caused by ***Endothia havanensis***. Turrialba (C.R.) 20(1): 94-99.

BORROR, D. J.; DeLONG, D. M.; TRIPLEHORN, C.A. 1976. An introduction to the study of insects. 4 ed. New York, EE.UU., Holt, Rinehart & Winston. 852 p.

BOYCE, J.S. 1961. Forest pathology. 3 ed. New York, EE.UU., McGraw-Hill. 572 p.

BRICEÑO, A.; RAMIREZ, J. 1976. ***Arsenura armida***, una plaga potencial del saquisaqui (***Bombacopsis quinata***). Boletín Forestal Venezolano 26 : 127-132.

BROWNE, F. G. 1968. Pests and diseases of forest plantation trees. Oxford, G.B., Clarendon Press. 1330 p.

CARLIN, K. D.; NUÑEZ, D. 1985. Insectos de conos y semillas en tres especies de pino en Honduras. ESNACIFOR (Hond.). Artículo Científico No. 6. 20 p.

CIBRIAN-TOVAR, D.; EBEL, B. H.; YATES, H. O.; MENDEZ-MONTIEL, J.T. 1986. Insectos de conos y semillas de las coníferas de México. Southeastern Forest Exp. Sta. Gen. Tech. Rep. SE-40 110 p.

CHAVERRI, A. 1983. Herbivorismo de orugas de la familia Lasiocampidae sobre una especie de roble. Brenesia (C.R.) 21: 461-463.

CHAVERRI, A. 1984. Defoliación de encinos por larvas de ***Dirphiopsis flora*** (Lepidoptera : Saturniidae) en Loma Larga de Cartago, Costa Rica. Ciencias Ambientales (C.R.) No 5-6: 85-90.

DAVIDSON, E. M.; TAY, F. C. S. 1987. The effect of waterlogging on infection of ***Eucalyptus marginata*** seedlings by ***Phytophthora cinnamomi***. New Pathologist 105(4): 585-594.

DELGADO, R. 1986. Observaciones sobre la construcción de túneles y el ciclo reproductivo de la taltuza ***Orthogeomys cherriei*** (Rodentia, Geomyidae). Tesis Lic. San José, Costa Rica. Universidad de Costa Rica, Escuela de Biología. 65 p.

DEMUNER, N. L.; ALFENAS, A. C.; CARVALHO, A. O.; ZAMBOLIN, L. 1987. Ocorrência e controle do tombamento de mudas de ***Leucaena leucocephala***, causado por ***Rhizoctonia*** sp. Fitop. Brasileira (Bra.) 12 (2): 120.

DIANESE, J. C.; HARIDASAN, M.; MORAES, T. S. 1984. Tolerance to "Mal do Rio Doce", a major disease of ***Eucalyptus*** in Brasil. Trop. Pest Management (G.B.) 30: 247-252.

DIANESE, J. C.; MORAES, T. S. 1986. Sintomatologia do "Mal do Rio Doce": enfermidade do eucalipto. Fitop. Brasileira (Bra.) 11(1): 249-258.

DIANESE, J. C.; RIBEIRO, W. R.; MORAES, T. S. 1984. ***Colletotrichum gloeosporioides*** (Penz) Sacc. em lesões de ramos de ***Eucalyptus pellita*** afetado pelo "mal do Rio Doce". Fitop. Brasileira (Bra.) 9(2):426.

DUFFY, E. A. J. 1960. A monograph of the immature stages of neotropical timber beetles (Cerambycidae). London, G.B., The British Museum of Natural History. 327 p.

FERREIRA, F. 1989. Patologia florestal; principais doenças florestais no Brasil. Viçosa, Bra., Centro de Investigações Florestais. 570 p.

FERREIRA, A. F.; DEMUNER, N. L.; ALFENAS, A.C.; REZENDE, D. V. 1988. Controle do tombamento de mudas de eucalipto no Estado de Minas Gerais. Fitop. Brasileira (Bra.) 13(2) : 128.

FIGUEREIDO, M. B.; NAMEKATA, T. 1969. ***Dothistroma pini*** Hulb. agente causal da queima a aciculas en ***Pinus*** sp., fungo recentemente observado no Brasil. Biológico (Bra.) 35 (3): 179-181.

FORD, L. B. 1981. Reconocimiento de las plagas de plantaciones forestales en Costa Rica. CATIE. Serie Técnica. Informe Técnico No. 7. 53 p.

FORD, L. B. 1982. ***Dothistroma*** in Costa Rica. Turrialba (C.R.) 32 (1): 75-82.

FORD, L. B. 1986a. El taladrador de los brotes del pino. Turrialba (C.R.) 36(2):245-248.

FORD, L. B. 1986b. El taladrador de ***Terminalia***. Turrialba (C.R.) 36 (2): 248-251.

GALLO, D. ***et al.*** 1978. Manual de entomología agrícola. Sâo Paulo, Bra., Editora Agronômica Ceres. 531 p.

GARA, R. I. 1970. Report of forest entomology consultant. UNDP Project 80. Turrialba, C.R., IICA. 21 p.

GIBSON, I. A. S. 1972. ***Dothistroma*** blight of ***Pinus radiata***. Ann. Rev. Phytopathol. (EE.UU.) 10 : 51-72.

GIBSON. I. A. S. 1974. Impact and control of dothistroma blight of pines. Eur. Jour. For. Pathol. (Germany) 4(2): 89-100.

GONZALEZ, V. R.; VELARDE, E.; ABAD, J. 1979. Chupadera fungosa de ***Pinus*** spp. en un vivero de Cajamarca. Rev. For. de Perú 9(2): 53-58.

GRAY, B. 1972. Economic tropical forest entomology. Ann. Rev. Entomol. (EE.UU.) 17: 313-354.

GRAY, B. 1978. Pests and diseases in forests and plantations. **In** Man and patterns of use of tropical forest ecosystems. UNESCO-UNEP-FAO. p. 286-314.

HALL, E. R. 1981. The mammals of North America. 2 ed. New York, EE.UU., John Wiley. v. 1-2, 1181 p.

HAMM, P. B. 1984. Response of ***Phytophthora*** spp. to metalaxyl in forest tree nurseries in the Pacific North-west. Plant Disease (EE.UU.) 68(8): 671-673.

HELDRIDGE, R. H.; DOWDEN, H. 1980. Susceptibility of five provenances of ponderosa pine to dothistroma needle blight. Plant Disease (EE.UU.) 64(4): 400-401.

HILJE, L.; QUIROS, L. 1985. Notas sobre la biología de ***Dirphiopsis flora*** (Schaus) (Lepidoptera : Saturniidae), defoliador de encinos (***Quercus*** spp.). Turrialba (C.R.) 36(3): 401-406.

HIRATSUKA, Y. 1987. Forest tree diseases of the prairie provinces Canadian Forestry Service. Information Report NOR-X-286. 142 p

HOCHMUT, R.; MANSO, D. M. 1982. Protección contra las plagas forestales en Cuba. Cuba, Editorial Científico-Técnica. 290 p.

HODGES, C. S. 1989. Visit to REFINSA, Guatemala (A consultant report). Raleigh, N.C., EE.UU., Zobel Forestry Assoc. 8 p.

HODGES, C. S.; GEARY, T. F.; CORDELL, C. E. 1979. The occurrence of ***Diaporthe cubensis*** in ***Eucalyptus*** in Florida, Hawaii, and Puerto Rico. Plant Dis. Reptr. (EE.UU.) 63(3): 216-220.

ISLAS, F. s.f. Observaciones sobre la biología y el combate de los escarabajos descortezadores de los pinos: ***Dendroctonus adjunctus*** Blf.; ***D. mexicanus*** Hpk. y ***D. frontalis*** Zimm., en algunas regiones de la República Mexicana. Inst. Nac. Invest. For. Bol. Téc. No. 66. 42 p.

JANZEN, D. H. 1979. Natural history of ***Phelypera distigma*** (Boheman), Curculionidae, a Costa Rican defoliator of ***Guazuma ulmifolia*** Lam. (Sterculiaceae). Brenesia (C.R.) 16: 213-219.

JANZEN, D. H. 1982. Guía para la identificación de mariposas nocturnas de la familia Saturniidae del Parque Nacional Santa Rosa, Guanacaste, Costa Rica. Brenesia (C.R.) 19/20: 255-299.

COSTA RICAN natural history. 1983a. Ed. by. Janzen, D.H. Chicago, EE.UU. The University of Chicago Press. 816 p.

JANZEN, D. H. 1983b. Larval biology of ***Ectomyelois muriscis*** (Pyralidae : Phycitinae), a Costa Rican fruit parasite of ***Hymenaea courbaril*** (Leguminosae: Caesalpinioideae). Brenesia (C.R.) 21: 387-393.

KING, A. B. S.; SAUNDERS, J. L. 1984. Las plagas invertebradas de cultivos anuales alimenticios en América Central. Londres, G.B., Overseas Development Administration. 182 p.

LARA, F. 1961. Cerambycidae and Scolytidae associated with cacao in Costa Rica. Tesis Ph. D. Madison, Wis., EE.UU. University of Wisconsin. 127 p.

LOPEZ, N. 1986. Control del mal de almácigo en semilleros de ***Pinus radiata***. Rev. Fac. Cienc. Agr. (Ec.) 13 (1-2): 38-43.

McPHERSON, A. B. 1985. A biogeographical analysis of factors influencing the distribution of Costa Rican rodents. Brenesia (C. R.) 23: 97-273.

MENDEZ, E. 1970. Los principales mamíferos de Panamá. Panamá, edición privada. 283 p.

MICHAIL, S. H.; EL-SAYED, A. B. 1986. ***Fusarium*** post-emergence damping off of ***Eucalyptus*** and its control measures in Egypt. Acta Phytopathol. et Entomol. Hungarica 21(1-2): 127-133.

MONGE, J. 1989. Ciclo reproductivo y dieta de la ardilla ***Sciurus variegatoides*** (Sciuridae, Rodentia) en la península de Nicoya, Costa Rica. Tesis Lic. Heredia, C.R., Universidad Nacional, Escuela de Ciencias Ambientales. 81 p.

MORA, J. M.; MOREIRA, I. 1984. Mamíferos de Costa Rica. San José, C.R., EUNED. 175 p.

MORENO, G. 1989. Biología de las especies de ***Phassus*** y ***Aepytus*** (Lepidoptera: Hepialidae) en localidades de elevación media en Costa Rica. Tesis Lic. Heredia, C.R., Universidad Nacional, Escuela de Ciencias Biológicas. 161 p.

MOSER, J. C. 1985. Use of sporothecae by phoretic ***Tarsonemus mites*** to transport ascospores of coniferous bluestain fungi. Trans. British Mycol. Soc. (G.B.) 84: 750-753.

NAIR, K. S. S. 1986. Important insect pest problems of forest plantations in tropical India. **In** IUFRO World Congress. (18., 1986). Proceedings. Division 2: Forest Plants and Forest Protection. p. 134-145.

NAPIER, J. 1982. Enfermedades fungosas de los pinos en los viveros de Honduras: identificación, prevención y control. ESNACIFOR (Hond.) Nota Técnica Vo. 3. 12 p.

NOWAK, R. M.; PARADISO, J. L. 1983. Walker's mammals of the World. 4 ed. Baltimore, EE.UU., The Johns Hopkins University Press. 1362 p.

OGOSHI, A. 1987. Ecology and pathogenicity of anastomosis and intraspecific groups of ***Rhizoctonia solani*** Kuhn Ann. Rev. Phytopathol. (EE.UU) 25: 125-143.

OROZCO, C. 1984. Determinación y control de las principales enfermedades que afectan viveros y plantaciones forestales en Colombia. **In** Curso "Aspectos básicos de enfermedades forestales". (1., 1986 Cartago, C.R.) [Acta], Cartago, C.R., Inst. Tecnol. de Costa Rica. p. irr.

PETERSON, G. W. 1984. Resistance to ***Dothistroma pini*** within geographic seed sources of ***Pinus ponderosa.*** Phytopathology (EE.UU) 74 (8): 956-960.

RADDI, P.; PANCONESI, A. 1981. Cypress canker disease in Italy: Control possibilities and genetic improvement for resistance. Eur. Jour. For. Pathol. (Germany) 11 (5-6): 340-347.

REUVENI, R.; MADAR, Z. 1985. The role of ***Macrophomina phaseolina*** in mortality of pine seedlings in forest nurseries. Phytopathologische Zeitschrift (Germany) 112 (2): 161-164.

RODRIGUEZ, R. 1982. Plagas forestales y su control en México. México, Universidad Autónoma de Chapingo, Dpto. de Parasitología. 187 p.

ROUX, C. 1984. The morphology of ***Dothistroma septospora*** on ***Pinus canariensis*** from South Africa. South Afr. Jour. Botany 3 (6): 397-401.

SALAZAR, R. 1984. Notas preliminares sobre el barrenador de los brotes terminales del pino, ***Rhyacionia frustrana*** (Lepidoptera; Tortricidae) en Costa Rica. Turrialba (C.R.) 34 (2): 250-252.

SEGURA, C. B. de. 1970a. La enfermedad rosada (***Corticium salmonicolor***) y el mal de hilachas (***Pellicularia koleroga***) sobre varias especies de ***Eucalyptus*** en Turrialba, Costa Rica. Turrialba (C.R.) 20 (2): 254-255.

SEGURA, C. B. de. 1970b. Manchas foliares causadas por el hongo ***Cylindrocladium scoparium*** Morg. en ***Eucalyptus*** spp. en Turrialba, Costa Rica. Turrialba (C.R.) 20(3): 365-366.

SEN-SARMA, P. K. 1986. Forest insect problems and their management in India. **In** IUFRO World Congress. (18., 1986) Proceedings. Division 2: Forest Plants and Forest Protection. p. 236-245.

SETH, S. K.; BAKSHI, B. K.; REDDY, M. A. R.; SINGH, S. 1978. Pink disease of eucalypts in India. Eur. Jour For. Pathol. (Germany) 8(4): 200-216.

SETH, S. K.; BAKSHI, B. K.; REDDY, M. A. R.; SINGH, S. 1978. Pink disease of eucalypts in India. Eur. Jour For. Pathol. (Germany) 8(4): 200-216.

SHARMA, J. K.; MOHANAN, C.; FLORENCE, E. J. M. 1984. Nursery diseases of ***Eucalyptus*** in Kerala. Eur. Jour. For. Pathol. (Germany) 14 (2): 77-89.

SHARMA, J. K.; MOHANAN, C.; FLORENCE, E. J. M. 1985. Disease survey in nurseries and plantations of forest tree species grown en Kerala. Kerala, India, Kerala Forest Res. Inst. 275 p.

SISK, T.; VAUGHAN, C. 1984. Notes on some aspects of the natural history of the giant pocket gopher (***Orthogeomys*** Merriam) in Costa Rica. Brenesia (C.R.) 22: 233-247.

STEHR, F. W. (ed.). 1987. Immature insects. Dubuque, Iowa, EE.UU., Kendall-Hunt Publ. 754 p.

SUTTON, B. C.; HODGES C. S. 1990. Revision of ***Cercospora*** -like fungi on ***Juniperus*** and related conifers. Mycologia (EE.UU.) 82(3): 313-315.

TAHA, K. H. ; AHMAD, K. A. ; OTHMAN, W. A.; MOHAMAD, N. Y. 1987. Identification of some fungi causing ***Eucalyptus*** damping off diseases in Ninevah and its chemical and biological control. Iraqui Jour. Agric. Science Zanco 5 (2): 225-232.

THATCHER, R. C.; SEARCY, J. L.; COSTER, J. E.; HERTEL, G. D. (eds.). s.f. The Southern pine beetle. U.S.D.A. Forest Service. S.E.A. Tech. Bull. No. 1631. 266 p.

PREVENTION AND control of wildlife damage. 1983. Ed. by Timm, R. M. Great Plains Agric. Council - Wildlife Resources Committee-Nebraska Coop. Ext. Serv. s.p.

TUSET, J. J.; HINAREJOS, C. 1985. Influencia del estado hídrico de los tejidos en la susceptibilidad de cipreses y palmares al ataque de dos especies de ***Pestalotiopsis***. Anales Inst. Nal. Inv. Agrarias (España) 28: 211-234.

VALDIVIESO, J. A.; LUISI, N. 1987. El cancro del ciprés [***Seiridium cardinale*** (Wag.) Sutt. et Gibbs] en Chile. Fitopatología (Perú) 22 (2): 79-84.

VALDIVIESO, J. A.; LUISI, N.; BRAVO, T. J. 1988. Susceptibilidad de las cupresáceas presentes en Chile hacia ***Seiridium cardinale***, agente causal del cancro de la corteza del ciprés. Bosque (Chile) 9(1): 9-15.

VAZQUEZ, I.; SANCHEZ, R. 1981. Identificación y control químico del "damping off" en el vivero forestal Lázaro Cárdenas. Rev. Ciencias For. (Méx.) 30 (6): 3-22.

WILLE, A. 1965. Las abejas atarrá de la región mesoamericana del género y subgénero ***Trigona*** (Apidae-Meliponini). Rev. Biol. Trop. (C.R.) 13 (2): 271-291.

WILLE, A.; FUENTES, G. 1970. Introducción al estudio de la taxonomía de los insectos (excepto Endopterygota). Publi caciones de la Universidad de Costa Rica. Serie Agronomía No. 15. 55 p.

WOOD, S. L. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae); a taxonomic monograph. Utah, Brigham Young University. Great Basin Naturalist Memoirs, No. 6. 1359 p.

ANNEX

LIST OF COMMON NAMES FOR PLANTS CITED IN THE TEXT

Scientific Name	Common names
Acacia mangium	Acacia
Albizzia guachapele	Guayaquil, conacaste blanco, gavilán, lagarto
Alnus acuminata	Alder, jaúl, aliso, ilamo
Astronium graveolens	Yoke, ron-ron, jobillo
Bombacopsis quinatum	Saquisaqui, false cedar, tolú, pochote, cedro espino ceibillo, espinoso
Caesalpinia velutina	Aripín, topoposte
Cajanus cajan	Pigeon pea, caupí, frijol de palo
Calliandra calothyrsus	Powderpuff, farolillo, pelo de ángel
Carica papaya	Pawpaw, papaya
Casuarina equisetifolia	She-oak, casuarina
Cedrela odorata	Cedar, cedro amargo, cedro, cedro real
Cordia alliodora	Cypre, salmwood, laurel
Cupressus lusitanica	Cypress, ciprés
Enterolobium cyclocarpum	Ear fruit, guanacaste, caro, conacaste orejero, corotú
Erythrina spp.	Mountain immortelle, coral tree, poró, elequeme, pito
Eucalyptus camaldulensis	Red river gum, red gum, eucalipto
Eucalyptus deglupta	Kamarere, bagras, leda, eucalipto
Eucalyptus saligna	Saligna gum, eucalipto
Fraxinus uhdei	Ash, fresno
Gliricidia sepium	Mother of cocoa, quick stick, Nicaraguan cocoa shade, madero negro, balo, madero, madreado, mata ratón
Gmelina arborea	Gmelina, goomar teak, yemane, Kashmir tree, melina, teca blanca
Guazuma ulmifolia	Guacima, bois d'orme, guácimo, caulote, guácimo de ternero, tapaculo
Hymenaea courbaril	Stinking toe, guapinol, copinol
Juglans olanchana	Walnut, nogal
Leucaena leucocephala	Leucaena, jimbay, ipil-ipil, guaje, yaje

Scientific Name	Common names
Mangifera indica	Mango
Manihot esculenta	Cassava, yuca
Mimosa scabrella	Bracatinga
Pinus caribaea	Caribbean pitch pine, Caribbean pine, pino de llano, pino de Petén, pino ocote
Pithecellobium saman	Raintree, cenízaro, ancho zorra, carreto, genízaro
Platymiscium pinnatum	Cristóbal
Psidium friedrichsthalianum	Wild guava, cas, arrayán, guayaba de fresco
Swietenia mahagoni	Mahogany, caoba
Tabebuia rosea	Pink pou, roble de sabana, maquilishuat, matilisguate
Tectona grandis	Teak, teca
Terminalia amazonia	Amarillón
Terminalia ivorensis	Idogbo, roble marfil
Terminalia oblonga	Surá, guayabón
Theobroma cacao	Cacao

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