

School of Environmental Biology

Bulletin No. 23

LEAF-EATING BEETLES IN BRAZILIAN EUCALYPT PLANTATIONS

Norivaldo dos Anjos¹ and Jonathan D. Majer²

¹ Department of Animal Biology, Federal University of Viçosa, Av. P. H. Rolfs, s/n, CEP: 36571-000, Viçosa, MG, Brazil.
CAPES (Brazil) grantee. E-mail: nanjos@ufv.br

² Department of Environmental Biology, Curtin University of Technology, PO Box U1987, Perth, WA 6845, Australia
E-mail: J.Majer@curtin.edu.au

2003-11-26

ISSN No. 0158 3301

SCHOOL OF ENVIRONMENTAL BIOLOGY BULLETIN

EDITORIAL BOARD

Prof J D Majer, Department of Environmental Biology, Curtin University of Technology

Adj Prof S J J F Davies, Department of Environmental Biology, Curtin University of Technology

Dr L E Koch, C/- Department of Environmental Biology, Curtin University of Technology

Information for Contributors

Biologists who wish to publish the results of their investigations have access to a large number of journals. For a variety of reasons, however, the editors of most of these journals are unwilling to accept articles that are lengthy, contain information that is preliminary in nature, or form the basis of addresses given at conferences. Nevertheless, some material of this type could be of immense interest and value to other scientists, and should be published. One avenue for dissemination of such material is the School of Environmental Biology Bulletin, a series of occasional papers published by Curtin University of Technology.

Intending contributors should contact Prof Majer, c/- the Department of Environmental Biology, GPO Box U1987, Perth, Western Australia 6845 (Tel. +61 08 9266 7041; Fax. +61 08 9266 2495). All submitted papers will be considered by the Editorial Board and appropriate referees. Publication costs for papers that are accepted must be met by authors or their employers.

Contents

| | |
|---|----|
| Preface | i |
| Abstract | 1 |
| 1.0 Introduction | 1 |
| 2.0 Chrysomelidae (Leaf Beetles) | 4 |
| 2.1 <i>Costalimaita ferruginea</i> (Fabricius, 1801) (Eumolpinae) | 5 |
| 2.2 <i>Sternocolaspis quatuordecimcostata</i> (Lefrève, 1877) (Eumolpinae) | 7 |
| 2.3 <i>Metaxyonycha angustata</i> (Perty, 1832) (Eumolpinae) | 8 |
| 2.4 <i>Metallactus quindecimguttatus</i> (Fabricius, 1775) (Cryptocephalinae) | 9 |
| 2.5 <i>Agathomerus sellatus</i> (Germar, 1823) (Megalopodinae) | 9 |
| 2.6 <i>Cacoscelis marginata</i> (Fabricius, 1775) (Alticinae) | 9 |
| 2.7 <i>Eumolpus surinamensis</i> Fabricius, 1775 (Eumolpinae) | 10 |
| 2.8 <i>Myochrous armatus</i> Baly, 1865 (Eumolpinae) | 10 |
| 2.9 <i>Metriona</i> spp. (Cassidinae) | 10 |
| 3.0 Buprestidae (Jewel Beetles) | 10 |
| 3.1 <i>Psiloptera argyrophora</i> (Perty, 1830) | 12 |
| 3.2 <i>Psiloptera attenuata</i> (Fabricius, 1794) | 12 |
| 3.3 <i>Psiloptera hoffmanni</i> (Castelnau et Gory, 1839) | 13 |
| 3.4 <i>Psiloptera pardalis</i> (Castelnau et Gory, 1836) | 13 |
| 3.5 <i>Lampetis cupreosparsa</i> (Lucas, 1859) | 13 |
| 3.6 <i>Lampetis dives</i> (Germar, 1824) | 13 |
| 3.7 <i>Lampetis doncheri</i> (Gory, 1840) | 13 |
| 3.8 <i>Lampetis instabilis</i> (Castelnau et Gory, 1836) | 13 |
| 3.9 <i>Lampetis solieri</i> (Lucas, 1859) | 14 |
| 4.0 Curculionoidea (Weevils) | 14 |
| 4.1 <i>Gonipterus scutellatus</i> Gyllenhal, 1833 and <i>G. gibberus</i> (Boisduval, 1835) (Gonipterinae) | 14 |
| 4.2 <i>Asynonychus cervinus</i> (Boheman, 1840) (Brachyderinae) | 16 |
| 4.3 <i>Naupactus longimanus</i> (Fabricius, 1775) (Brachyderinae) | 16 |
| 4.4 <i>Naupactus xanthographus</i> (Germar, 1824) (Brachyderinae) | 17 |
| 4.5 <i>Naupactus bipes</i> (Germar, 1824) (Brachyderinae) | 17 |
| 4.6 <i>Naupactus condecoratus</i> (Boheman, 1840) (Brachyderinae) | 17 |
| 4.7 <i>Naupactus elegans</i> Lucas, 1859 (Brachyderinae) | 17 |
| 4.8 <i>Lasiopus cilipes</i> (Sahlberg, 1823) (Leptosinae) | 18 |
| 4.9 <i>Miremorphus eucalypti</i> Bondar, 1950 (Dinomorphinae) | 18 |
| 4.10 <i>Phaops adamantina</i> (Germar, 1824) (Otiiorhynchynae) | 18 |
| 4.11 <i>Rhigus tribuloides</i> Pallas, 1781 (Leptosinae) | 18 |
| 4.12 <i>Cyphus luridus</i> Boheman, 1840 (Brachyderinae) | 18 |
| 4.13 <i>Heilipus fallax</i> Boheman, 1843 (Hylobiinae) | 18 |
| 4.14 <i>Hoplopactus injucundus</i> (Boheman, 1833) (Brachyderinae) | 19 |
| 4.15 <i>Hypsonotus</i> sp. (Leptosinae) | 19 |
| 5.0 Scarabaeidae (Spring Beetles) | 19 |
| 5.1 <i>Bolax flavolineata</i> (Mannerheim, 1829) | 19 |
| 5.2 <i>Geniates barbatus</i> Kirby, 1818 | 20 |
| 5.3 <i>Leucothyreus niveicollis</i> Laporte, 1840 | 20 |
| 5.4 <i>Philoclaenia tricostata</i> Burmeister, 1855 | 21 |
| 6.0 Coccinellidae (Ladybird Beetles) | 21 |
| 6.1 <i>Epilachna clandestina</i> Mulsant, 1850 (Epilachninae) | 21 |
| 7.0 Other Leaf-Eating Beetles | 22 |
| Figures | 23 |
| 8.0 Integrated Pest Management | 26 |
| 9.0 Acknowledgements | 29 |
| 10.0 References | 29 |

Abstract

Tree plantations in Brazil are grown for pulp, paper, charcoal, rubber, vegetable oil, resin, tannin, fuel, shade for livestock and for the furniture industry. Although tree plantations must be established in an ecologically sustainable manner, as with all crops a forest plantation needs to be profitable in order to maintain itself as an agribusiness activity. An exception is when they are used for land revegetation or soil rehabilitation. Many different species have been used in tree plantations in Brazil, but eucalypts are the most predominant cultivated trees. However, many problems have arisen with eucalypt plantations, as has happened with other types of monocultures. Pest outbreaks are among these problems, as numerous native insects have become serious pests in these plantations. Brazilian involvement with eucalypts began in 1904 and, to date, more than 200 invertebrate species are known to be harmful to the plantations. Defoliators, such as leaf-cutting ants, caterpillars, and leaf-eating beetles are the most important groups of pests. Problems with leaf-eating beetles began in 1925, when the Australian weevil *Gonipterus scutellatus* was introduced in the Argentine, and then into the Brazilian eucalypt plantations. The first major problem associated with a native leaf beetle arose in 1953, when the chrysomelid *Sternocolaspis quatuordecimcostata* was reported as a serious pest of eucalypts plantations. Currently, more than 40 leaf-eating beetles species have been reported as eucalypt pests; the most important species being *Costalimaita ferruginea* (Chrysomelidae), *Gonipterus scutellatus* (Curculionidae), *Bolax flavolineata* (Scarabaeidae) and *Lampetis nigerrima* (Buprestidae). The life histories of these insects have not been substantially studied and their economic importance has only been delimited for a few species. Chemical sprayings have been the main control technique to relieve pest outbreaks. However, appropriate technology for preventing outbreaks and making control decisions are in progress to avoid chemical interventions in the Brazilian forestry operations.

1.0 Introduction

In Brazil, about 5.4 million hectares of planted forests are grown for pulp, paper, charcoal, rubber, vegetable oil, resin, tannin, fuel, livestock shading and the furniture industry. Native tree species used in forest plantations include: Paraná Pine *Araucaria angustifolia*, Pará Rubber Tree *Hevea brasiliensis*, Bracatinga *Mimosa scabrella*, Angico *Piptadenia* spp., Tree Fern *Schizolobium parahyba*, Brazilian Rose Wood *Dalbergia nigra*, Golden Trumpet Trees *Tabebuia* spp., Imbuia *Ocotea porosa* and Heart palm *Euterpe edulis*, plus a range of other minor species.

Although many different tree species are used in tree plantations, eucalypts are the most predominant trees; about 62% of the Brazilian plantation estate is covered by this tree genus (Table 1).

Table 1. Brazilian forested areas used for pulp/paper production, expressed as a percentage of total plantation area and broken down by State (data for December 31, 1996).

| Brazilian State | Eucalypt | Tropical Pine | Paraná Pine | Acacia | Gmelina | Other Trees | Total |
|-----------------|--------------|---------------|-------------|-------------|-------------|-------------|---------------|
| SP | 18.04 | 2.69 | 0.01 | 0.00 | 0.00 | 0.15 | 20.89 |
| PR | 3.35 | 14.75 | 0.88 | 0.00 | 0.00 | 0.25 | 19.22 |
| BA | 13.73 | 2.74 | 0.00 | 0.00 | 0.00 | 0.27 | 16.74 |
| MG | 8.88 | 0.23 | 0.08 | 0.00 | 0.00 | 0.13 | 9.32 |
| SC | 1.04 | 7.78 | 0.20 | 0.00 | 0.01 | 0.01 | 9.04 |
| AP | 0.89 | 5.70 | 0.00 | 0.01 | 0.00 | 0.00 | 6.60 |
| ES | 6.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.21 |
| RS | 4.05 | 0.84 | 0.07 | 0.03 | 0.00 | 0.05 | 5.03 |
| PA | 2.82 | 0.73 | 0.00 | 0.00 | 0.00 | 0.02 | 3.57 |
| MS | 2.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.83 |
| MA | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 |
| RJ | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| Total | 62.38 | 35.45 | 1.24 | 0.04 | 0.01 | 0.89 | 100.00 |

Source: Relatório Estatístico -ANFPC

The most widely cultivated eucalyptus are *Eucalyptus grandis*, *E. urophylla*, *E. saligna*, *E. tereticornis*, *E. camaldulensis*, *E. viminalis*, and *Corymbia citriodora* (BERTI FILHO, 1981). However, other exotic trees, such as Black Wattle *Acacia mearnsii*, Mange Tree *Acacia mangium*, Teak Tree *Tectona grandis*, Gmelina *Gmelina arborea*, Silkyoak *Grevillea robusta*, Princess Tree *Pawlonia tomentosa*, Chinese Fir *Cunninghamia lanceolata*, Oil Palm *Elaeis guineensis*, Coconut *Cocos nucifera* and Mesquite *Prosopis juliflora* are also part of the Brazilian forest estate (IBGE, 1981). In addition to this plantation area, an area equivalent to that covered by the above crops is under native forest plantations, and is under protection by the same plantation owners (Table 2).

This kind of tree cultivation functions as a regular crop activity and cannot be confounded with land revegetation and soil rehabilitation, where trees are planted for a different reason. Although tree plantation must be established on an ecologically sustainable basis, as with all crops a forest plantation needs to be profitable in order to maintain itself as an agribusiness activity. In this way, the Brazilian pulp and paper industry, for example, plants an annual total of about

300,000,000 of trees, which greatly lessens the need to cut down native forests and boosts jobs in areas where other agricultural crops are not profitable.

Table 2. Utilization of farmland in Brazil, expressed on a hectare and percentage basis.

| Land Usage | Hectare | % |
|-------------------------|------------|-------|
| Natural pastures | 78,048,463 | 22.07 |
| Pasture plantations | 99,652,008 | 28.18 |
| Temporary crops | 34,252,828 | 9.69 |
| Permanent crops | 7,541,625 | 2.13 |
| Resting croplands | 8,310,028 | 2.35 |
| Unused croplands | 16,360,085 | 4.63 |
| Inappropriate farmlands | 15,152,600 | 4.28 |
| Natural forests | 88,897,582 | 25.14 |
| Forest plantations | 5,396,015 | 1.53 |

Source: IBGE

Many problems have arisen with eucalypt plantations, as they have with other types of monocultures, and pest outbreaks are included among them. Eucalypt trees are classified in the same botanical family (Myrtaceae) as some Brazilian plants, and many native insects have become serious pests because they have switched from members of the native Myrtaceae to eucalypts (OGLOBIN, 1935; MARICONI, 1956). Almost one hundred fruit plants from the Myrtaceae family are known to be native in the Brazilian landscape (IPGRI-UCV and IPGRI/CIRAD-FLHOR, A. A. 6713, Cali, Colombia, <http://patula.ciat.cgiar.org/>). They include members of the genera *Acca* (1 species), *Britoa* (2 species), *Campomanesia* (11 species), *Eugenia* (26 species), *Gomidesia* (2 species), *Marliera* (50 species), *Myrcia* (5 species), *Myrcianthes* (2 species), *Myrciaria* (11 species), *Myrtus* (5 species), *Paivaea* (1 species), *Pseudanmomis* (1 species) and *Psidium* (19 species). OHMART and EDWARDS (1991) focused on insect herbivores on eucalypts and stated that in tropical eucalypt plantations, the most economically important herbivores have been indigenous insects that have adapted to eucalypts, rather than those accidentally introduced from Australia. In Brazil, since tropical conditions predominate in all plantation sites, it appears that some Brazilian native beetles are adapting themselves to this crop and are becoming important pests. The creation of large planted areas has facilitated this adaptive process, and insect outbreaks have become more frequent with the expansion of this planted area (see ANJOS *et al.*, 1987). A chapter looking in detail at a selection of major pest species from all over the tropical world has been produced by SPEIGHT and WYLIE (2001).

The first noxious insects in eucalypt plantations in Brazil were reported just five years after the first eucalypt research program was launched (ANDRADE, 1909). Until 1962, 98 species were

reported as living on eucalypt trees in Brazil (SILVA *et al.*, 1968), but in the next 18 years this number reached 216 species, belonging to 60 families and eight taxonomic orders (BERTI FILHO, 1981). This figure did not include leaf-cutting ants and termites. Leaf-cutting ants, caterpillars, leaf-eating beetles and termites are considered as the four most important groups of pests in Brazilian eucalypt plantations (ANJOS, 1992).

Problems with leaf-eating beetles surfaced in 1925 when the Australian weevil *Gonipterus scutellatus* was found in Argentinean eucalypt plantations (MARELLI, 1926). The Brazilian government and researchers were unable to avoid this insect spreading into Brazilian eucalypt plantations and, in 1954, it was reported in Brazilian eucalypt plantations (KOBBER, 1955). The first big problem with native leaf beetles arose in 1953, when *Sternocolaspis quatuordecimcostata* was reported as a serious pest of eucalypts plantations in São Paulo State (ORLANDO *et al.*, 1954). Since that time, leaf-eating beetles have become more serious pests of eucalypts in Brazil. This growing pest status has been accompanied by an increase in the occurrence of large outbreaks of leaf-eating beetles in eucalypt plantations (MENDES *et al.*, 1998; MENDES, 1999).

Nowadays, more than 40 leaf-eating beetle species have been reported as eucalypt pests, and the importance of this group is growing with the expansion of eucalypt crops. Leaf-eating beetles, which are considered as the third most important group of insect pests attacking eucalypts in Brazil (BERTI FILHO, 1981), include chrysomelids, weevils, spring beetles, and jewel beetles. The most important pest species are *Costalimaita ferruginea* (Chrysomelidae), *Gonipterus* spp. (Curculionidae), *Lampetis* spp. (Buprestidae), and *Bolax flavolineata* (Scarabaeidae). In addition, the ladybird beetle *Epilachna clandestina* (Coccinelidae) and some longicorn species, such as *Callipogon luctuosum* (Cerambycidae), have been reported as attacking leaves in Brazilian eucalypt plantations (BERTI FILHO, 1981).

The life history of these insects is not well studied, but leaf beetles are very deleterious to the eucalypt production in many countries in the world (ELLIOTT *et al.*, 1998; SPEIGHT & WYLIE, 2001).

2.0 Chrysomelidae (Leaf Beetles)

Beetles in this group are popularly known in Brazil as "vaquinhas" (=little cows), and they constitute a group of great importance as pests in Brazilian agroforestry. In particular, species from the subfamily Eumolpinae represent great concern because their larvae and adults are pests in the greatest number of crops in Brazil (LIMA, 1952).

Chrysomelids are polyphagous beetles that feed upon many plants, including coniferous species; adults usually eat foliage, and sometimes fruits (BOOTH *et al.*, 1990). Being polyphagous, they can be serious pests of many crops such as pines, eucalypts, acacias, cotton,

coffee, cocoa, vines, sweet potato, tea tree, cereals, sugar-cane, soy, okra, palms, rubber trees, guava, etc. Leaf beetles are also believed to be responsible for the transmission of several crop viruses.

Among the many Brazilian chrysomelids, the following species are pests in eucalypt plantations: *Costalimaita ferruginea*, *Sternocolaspis quatuordecimcostata*, *Colaspis quadrimaculata*, *Metallactus quindecimguttatus*, *Agathomerus sellatus*, *Cacoscelis marginata*, *Eumolpus surinamensis*, *Metaxyonycha angusta*, *Myochrous armatus*, and *Metriona* spp.

2.1 *Costalimaita ferruginea* (Fabricius, 1801) (Eumolpinae)

Costalimaita ferruginea (Fig. 1A) is the most important eucalypt leaf beetle pest in Brazilian commercial plantations (ANJOS, 1992). It is among the six pests that cause the greatest damage to eucalypt plantations in São Paulo (MACEDO, 1975). It occurs in other South American countries, from Argentina to Venezuela (LIMA, 1955, ALEMÁN, 1991), where it is mainly called "Eucalypt Yellow Beetle" (ANJOS, 1992).

Our knowledge of this insect derives from ANJOS (1992). According to this author, adults are dorsally yellowish and ventrally orange (females) or orange to black (males). However, the colour may change depending on how the insect is kept. Under natural conditions, females are slightly larger than males and there are two males to every three females. The insects have an elliptical body and measure from 5.0 to 6.5 mm long and are 3.0 mm to 3.5 mm in width. The eyes are black and each elytron has small, circular punctuations in 16-18 longitudinal striae. The males are smaller, weigh less, are more numerous and have a shorter life-span than the females. The egg is yellowish with a smooth corium. The mean number of eggs per female is 91.0 ± 5.8 , the mean incubation period is 8.8 ± 0.1 days and the mean egg viability is $86.92 \pm 2.05\%$. Eggs are released in the ground where the insect spends its larval stage and also pupates. It breeds profusely, but most of its life cycle remains unknown. Only the first and second instar larvae are known; they are whitish and probably feed on plant roots, which are not attacked by adult beetles (IGLESIAS, 1916). According to ANJOS (1992), larvae of *C. ferruginea* could be nurtured in neighbouring pasturelands and sugar-cane crops, which are always large in extent.

Adults swarm in large numbers in the evening, and are very active during the early part of the night. During the day, they hide inside tubes made of dried leaves or rest under leaves. Pest outbreaks are very common in the States of Minas Gerais, Mato Grosso do Sul and São Paulo, beginning in September and finishing in February. Heavy infestations of adults have been observed between September and March, with most population peaks occurring between October and December.

The Brazilian host plants of *C. ferruginea* include 19 species and 2 hybrid species of *Eucalyptus*, together with many other plants belonging to the Myrtaceae family (ANJOS, 1992). Suriname Cherry *Eugenia uniflora*, Jambolão *Eugenia cuminii*, Guava *Psidium guajava*, Wild Guava *P. guineense* and more than 11 species of *Eucalyptus* were revealed to be host plants in Brazil. Based on records of attacks to eucalypts, this author concluded that the most widely attacked species were *E. grandis* and *E. urophylla*. Adults of this insect are considered to be the most frequently occurring leaf-eating beetle in Brazilian eucalypt plantations (BERTI FILHO, 1984).

Although adults of the “Eucalypt Yellow Beetle” attack trees of any age, their damage seems to be more important in young plantations (Fig. 1B) and at the sprouting stage of second rotation forests (ANJOS, 1992). Adults attack recently planted seedlings and saplings from two months (ANJOS *et al.*, 1987 and ANJOS *et al.*, 1990) through to two years of age (PINHEIRO, 1962; ANDRADE, 1961), as well as young sprouts or mature trees (MACEDO, 1975). ANJOS (1992) reported great losses of seedlings in over 50% of replantings in some regions of the Paraná and Mato Grosso do Sul Brazilian States. They also feed on seedlings in nursery conditions (SILVA *et al.*, 1968; LINK & COSTA, 1984; BERTI FILHO, 1985). According to LINK and COSTA (1984), in the nursery three successive losses of foliage inflicted by the adult was sufficient to cause the death of the plants. ANJOS (1992) verified that affected plantations are predominantly those less than one year of age, but plantations up to 12 years after planting and sprouts up to 15 years of age are also attacked. The size of the affected plantations varies from small farm plantations (MARICONI, 1956) up to 213 hectares (ANJOS *et al.*, 1987), but adults of this insect can attack areas as large as 11,000 hectares (ANJOS, 1992).

The adult of this leaf beetle feeds on the soft tips of young branches, and also on the main tree shoot, leaves, and bark of branches. Attack on the plants always begins on the apex of the tree canopy. The intensity of initial attack in young eucalypts can be indicated by the frequency of main shoots that are cut off. In the case of leaves, the adults make perforations, irregularly rounded, which can join and form long galleries. If leaves are tender, those areas can be bigger; if mature, the thickest nerves will not be eaten and the leaves are skeletonized. The importance of the attack on the upper part of the tree canopy is that apical leaves and shoots play a very active role in the growth of the trees (KRAMER & KOZLOWSKI, 1972). The interruption of this physiological process causes harmful consequences to the production and quality of the trees (MENDES, 1999). That is more serious in the phase of initial growth of the tree and in the areas where growth rate is high. As a consequence of attack by the “Eucalypt Yellow Beetle”, the loss of 75% or more of the canopy foliage can prevent tree development, or the death of less developed trees. In the study carried through by MENDES (1999), a single event of complete foliage loss was enough to magnify significantly the percentage mortality among those trees that were more

severely damaged by this leaf beetle. Intermediate loss levels of canopy foliage also modified patterns of growth of trees and uniformity of the forest plantation, causing a reduction in wood production and tree quality.

The effect of the adult's attack on forest productivity is has been studied (ANJOS, 1992; MENDES, 1999). The wood production loss in *E. grandis* plantations due to the "Eucalypt Yellow Beetle" was initially assessed by ANJOS (1992), one year after a severe attack. This author found that reduction in tree diameter growth was 14.06%, while the reduction in height growth was 7.69%, and the consequent reduction in the wood volume was 33.02%. The tree does not recoup the loss in the vertical growth, because its greatest capacity to increase in height is in the beginning of its growth phase (KRAMER & KOZLOWSKI, 1972). Research in another situation by MENDES *et al.* (1998) revealed losses of 33.97% of the wood volume of *E. grandis*, less than one year after *C. ferruginea* attack. Tree trunk quality was significantly affected and this may cause problems for mechanical log exploitation.

2.2 *Sternocolaspis quatuordecimcostata* (Lefrève, 1877) (Eumolpinae)

Amongst leaf-eating beetles, this is a very important eucalypt pest in Brazil. As a polyphagous species, adults of this leaf-eating beetle have been reported on plants from many families such as Lauraceae, Rosaceae, Malvaceae, Convolvulaceae, Sterculiaceae, Anacardiaceae, Graminae, Fabaceae and Vitaceae (SILVA *et al.*, 1968). This insect occurs in the states of Pará, Rio Grande do Norte, Maranhão, Bahia, São Paulo, Santa Catarina and Paraná (JUNQUEIRA, 1962).

The adult of *S. quatuordecimcostata*, also known as "Limeira Beetle", was described by ORLANDO *et al.* (1954) as a beetle of generally bluish coloration with reddish, metallic, shining highlights. The male measures from 7 to 7.6 mm of size and the female from 9.2 to 10.0 mm (Fig. 2A). Its head and prothorax are a shining green colour, and the prothorax is wider than long, with very small and circular punctuations. The scutellum is green and smooth, and the elytra are a brilliant greenish or green-blue copper colour. Each elytron, seen from above, has seven longitudinal striae with circular punctuations between them. The ventral region of the body is of a bluish colour. According to those authors, inseminated females lay large amounts of yellow eggs in the ground at about 5mm depth, where litter covers the surface. The larvae and pupae live in the ground, but details of its biology are mainly unknown. Probably, larvae feed on decomposing litter. The adults swarm in huge numbers, mainly from October to February.

The pest status of this insect was only recognized in Brazil in 1953. It was the first serious problem with native leaf-eating beetles in Brazilian eucalypt plantations. According to ORLANDO *et al.* (1954), adults caused great damage in eucalypts and other plants in Limeira city

(São Paulo State) from November to January 1953. The beetle was reported in other years before, but not as such a serious threat. On affected eucalypt plantations, damage reached a point where no leaf remained after an attack. *Corymbia citriodora* was the most damaged eucalypt, where the insects also ate bark on branches, killing them. The attack to leaves can be characterized as enlarged holes at distinct points in the same leaf (Fig. 2B). In some plants, attack was also observed in the fruits. The most susceptible eucalypts were *C. citriodora* and *E. alba*. It was observed that *E. saligna* was less often attacked and *E. maidenii* was immune against the attack of this harmful insect. By 1955 and 1954, this insect erupted again and caused large damage, due to the huge number of insects and the voracity of the beetles. According to MARICONI (1956), *E. saligna* experienced only small outbreaks, but *Corymbia maculata*, *C. citriodora*, *E. alba* were highly susceptible to this beetle, although *E. globulus* was immune.

The intensity of the damage is related to the number of adults and to the species attacked, since some eucalypt species are preferred over others; in less preferred eucalypt species, attack does not become a issue (ORLANDO *et al.*, 1954).

2.3 *Metaxyonycha angustata* (Perty, 1832) (Eumolpinae)

Leaf beetles in this genus form a group with more than a dozen pest species, all of which attack leaves of many crops in Brazil. Their hosts can be such myrtaceous trees such as guava, jabuticabeira and eucalypts, or plants of other families such as Sterculiaceae, Vitaceae, Palmaceae, Solanaceae, Euphorbiaceae, Rosaceae, Cucurbitaceae, Graminae, and Fabaceae (SILVA *et al.*, 1968).

M. angustata is a leaf beetle popularly known as “Four-spot Beetle”, and it was first found feeding on eucalypts; no other host plant is known at present. It was reported as attacking eucalypt leaves in the Minas Gerais plantations, where it is known as “Vaquinha-do-Eucalipto” (LIMA, 1955). As a eucalypt pest, adults have been reported in French Guyana and Brazil, where their occurrence was reported for Santa Catarina, São Paulo, Amazonas, Pará and Minas Gerais states (BECHYNÉ, 1953; MARICONI, 1956). According to the latter author, the adult of this leaf beetle is yellow-ferruginous and, on the elytra, four large spots of green-bluish colour are present, forming a cross-shaped space (Fig. 3A). The antennae are long and almost black, and the legs are long and yellow, but the tarsi are dark. The beetles have black eyes and the ventral part of the beetle’s body is yellowish with dark margins; the prothorax is orange and narrow. The size of the body varies between 8 and 10 mm, but is greatly variable between the sexes. The beetles are not gregarious because they tend to move constantly between twigs or trees. This leaf beetle immediately flies when disturbed, as is common in all chrysomelids. Although *M. angustata*

seems to be common in Brazilian eucalypt plantations from November to January months, its damage remains unstudied.

Defoliation caused by *M. angustata* occurs in the upper part of the tree canopy to about one meter from the tree apex (Fig. 3B). The adults of this leaf-eating beetle eat soft tips, new shoots and unexpanded leaves. They do not skeletonise properly and, although causing pin-prick type damage initially, they ultimately eat the whole leaf limb. Mature leaves are not eaten very frequently.

Outbreaks of this insect were reported by MARICONI (1956) from 1953 to 1956 on eucalypts in the São Paulo plantations. In late-October 1991, adults of *M. angustata* appeared in huge numbers in *E. grandis* cultivated in the Mogi-Mirim shire (São Paulo), where they voraciously attacked trees of about one year age. That plantation was bounded by sugar-cane and native forests. Eucalypt trees were about 5 m tall, well nourished, apparently with no signs of water stress and no physiological abnormalities, although the outbreak was reported just after the first shower following a long drought period.

2.4 *Metallactus quindecimguttatus* (Fabricius, 1775) (Cryptocephalinae)

Brazilian Cryptocephalinae beetles are typically insects living on myrtaceous plants. Adults of these insects eat leaves of native guavarazil (SILVA *et al.*, 1968). *M. quindecimguttatus* has been reported as a pest of eucalypt in Rio de Janeiro plantations. BERTI FILHO (1981) recorded this insect causing damage to *E. grandis*, *E. saligna* and *E. urophylla* in Espírito Santo plantations.

2.5 *Agathomerus sellatus* (Germar, 1823) (Megalopodinae)

This insect is a pest in solanaceous crops, such as tomatoes and potatoes, where larvae are stem borers and adults are leaf eaters (LIMA, 1955). BERTI FILHO (1981) found adults of *A. sellatus* (Fig. 4A) causing damage on eucalypt foliage in the Espírito Santo plantations.

2.6 *Cacoscelis marginata* (Fabricius, 1775) (Alticinae)

This insect is a pest on Passifloraceae (*Passiflora vernicosa* and *P. edulis*). Adults of *C. marginata* (Fig. 4B) were found eating leaves of 6-year-old *E. saligna* in São Paulo plantations (ANDRADE, 1961). They were recorded from Rio de Janeiro and Minas Gerais states; in the latter state, they also attack native Cecropiaceae trees (SILVA *et al.*, 1968).

sunlight in the forest. The loss in height, caused by insect attack in the first year of age, is never compensated for, because it is the initial phase of the tree's development that determines its ultimate growth potential. After this age, affected trees are not able to take advantage of all site conditions.

During late October to early December 1992, a large outbreak of *Lampetis pulverea* and *L. elegans* was observed in *E. grandis* plantations located in south of Bahia (Caravelas) and north of Espírito Santo (Pedro Canário) states. This region is inside the Atlantic rainforest, where high humidity and temperatures levels are common. In this case, adult beetles ate the main shoot of the young trees and the tips of lateral branches. The mean damaged tree frequency was 66%, varying from 48 to 75% per plot. The biggest concentration of damaged trees was located in the confluence with natural forest. Losses of tree tips, including the main shoot, was 6.2 per tree (varying from 2.6 to 8.7 per plot). By removing the main shoot, these beetles blocked growth in height and caused trees to produce vigorous lateral sprouts. These changes in the normal tree growth resulted in significant losses in trunk shape and tree survival. Losses in the log production certainly resulted from the outbreak, but were not evaluated. Regions and periods of high productivity should result in higher economic losses and more serious management problems than those with lower productivity rates. However, such losses are only perceived through comparisons between healthy and damaged trees. In the outbreak just mentioned, high frequencies of forked trees were observed, but no mechanical consequences during tree harvest were evaluated. Besides these reported species, BERTI FILHO (1981) had collected *Psiloptera attenuata* and *Lampetis nistabilis* in *E. grandis* leaves in the Espírito Santo plantations.

Recently, at the end of 2001, adults of *L. nigerrima* (Fig. 6A), *L. instabilis* (Fig. 6C) and *L. cicatricosa* attacked all young (four months) *E. urophylla* in 2,016 hectares of plantations in the northeast of Minas Gerais state. All eucalypt plants were damaged, but 471 hectares of them were totally lost, and replanting was necessary in the following year. Corrective pruning and new fertilizing were necessary in 26% of the remain trees. At the end of 2002, adults of *L. nigerrima* and *L. instabilis*, attacked 1,430 hectares of *E. urophylla*, one to four months after they had been planted in another region. Beetles from 86.96% of this plantation needed to be controlled by hand-picking to avoid significant damage. Some plantation compartments were hand-picked five times while others were only picked once. The amount of hand-picked adults ranged from 5.6 adults/ha to 1,237 beetles/ha, according to the soil types, highly organic soils were more infested than poor soils. The outbreak started on November 2002, after first rains, and only finished at the end of March, 2003.

Beetles in this group are well known because most of them are colourful and very attractive to beetle collectors throughout the world. However, biological studies on this group are rare, because most of the species have a different host during their larval phase to that of which

2.7 *Eumolpus surinamensis* Fabricius, 1775 (Eumolpinae)

Eumolpus is the most known chrysomelid genus, on account of its coloration. BERTI FILHO (1981) found adults of *E. surinamensis* causing damage to leaves of *C. citriodora* in Espírito Santo plantations.

2.8 *Myochrous armatus* Baly, 1865 (Eumolpinae)

Adults of this leaf beetle (Fig. 5) have been reported attacking leaves of young eucalypts in the Rio de Janeiro plantations (LIMA, 1955).

2.9 *Metriona* spp. (Cassidinae)

At least six species, *M. elatior* (Klug, 1829), *M. sejunta* (Boheman, 1855), *M. sexpuncta* (Fabricius, 1781), *M. stulta* Boheman, 1855, *M. tenella* (Klug, 1829) and *M. virgulata* (Boheman, 1855) are known in Brazil as insects whose adults feed upon Convolvulaceae and Solanaceae leaves. More than one of them attacks eucalypt leaves in Paraíba plantations, in the northeast of Brazil (SILVA *et al.*, 1968).

3.0 Buprestidae (Jewel Beetles)

Brazilian insects of the *Psiloptera* and *Lampetis* genera, which belong to the Buprestidae, are known as "Besouro Cai-cai" (Drop-Drop beetle) or "Besouro Manhoso" (Cunning Beetle), because the adult insect drops to the ground looking when disturbed.

This is a special group of leaf-eating beetles that are of growing importance as eucalypt pests in Brazilian plantations. The problem mainly started after forest companies started planting with no cultural preparation of soils. Dead trunks, log dumps and other logging products are good places for jewel beetles to develop.

"Cai-cai beetles" appear in great numbers in the beginning of the summer, and attack young trees. As a pest, adults of "Cai-cai beetles" eat the tips of lateral branches and chew the main shoot of young eucalypts. Damage worsens when they eat the main shoot, because this event will stop the vertical growth. Consequently, trees will produce a vigorous but deformed lateral sprout. The tree will take time to resume the apical growth, and this delay will cause the biggest losses on trees with the highest growth rates. Such damaged trees may be scattered among healthy trees, resulting in less vigour and competitive ability. This mixed stand can result in an accentuated increase in the number of affected trees, which will be killed by competition for

they use as adults. According to LIMA (1953), jewel beetles have a compact body because they have a strong linkage between the prothorax and the remainder of the body. The tegument is strongly hardened, and beetles are noticeable by their bright colours, which are commonly metallic. Although the biology of the “Cai-cai beetles” in Brazil is not well known, females lay their eggs in declining and dead trees or in recently cut trunks and stumps of eucalypts and pines. The adult phase in natural conditions may be very long-lived. The female inserts eggs in the tree bark, where the hatched larvae can get in to wood to feed and grow. The tunnel made by the larvae in wood is elliptical and is the most flattened tunnel known to be produced by insect borers. Many larvae take a long time to reach full growth, and eggs released during December to March will complete their development in the following summer, or two years after. Larvae have a characteristic shape that looks like a key, because their head is small and partially retracted in the prothorax. The prothorax itself is strongly widened, flattened, with hardened plates on both sides. The abdomen is long and sub-cylindrical, with clear segmentation (buprestoid larva). Many jewel beetle larvae and adult phases can cause economic losses in terms of wood production and quality.

According to SILVA *et al.* (1968) and BERTI FILHO (1981), the jewel beetles identified as eucalypt leaf feeders in the Brazilian plantations are: *Psiloptera argyrophora*, *P. attenuata*, *P. hoffmanni*, *P. pardalis*, and *Lampetis cupreosparsa*, *L. dives*, *L. doncheri*, *L. instabilis*, and *L. solieri*. Many other Buprestidae species, such as *Lampetis hirtomaculata*, *Conognata magnifica*, *Chrysobothris* sp. and *Psiloptera* sp. have also been associated with eucalypt trees in Brazil (PINHEIRO, 1954; ANDRADE, 1961; SILVA *et al.*, 1968; BERTI FILHO, 1981; RIBEIRO & ZANUNCIO, 2000), but not yet as leaf feeders.

3.1 *Psiloptera argyrophora* (Perty, 1830)

This insect has been reported by SILVA *et al.* (1968) as a pest of eucalypt leaves in São Paulo plantations. This species also was reported in Goiás State by KERREMANS (1903).

3.2 *Psiloptera attenuata* (Fabricius, 1794)

Adults of this insect has been reported by SILVA *et al.* (1968) as eating leaves of *E. urophylla*, *E. saligna* and *C. citriodora* in Minas Gerais state, and *Citrus sinensis* in the Rio Grande do Norte state. BERTI FILHO (1981) observed it eating leaves of *E. grandis* and *E. saligna* in Espírito Santo plantations. This species may be widespread in all southern and northern Brazilian regions.

3.3 *Psiloptera hoffmanni* (Castelnau et Gory, 1839)

BERTI FILHO (1981) found adults of this insect attacking leaves of *C. citriodora* in Espírito Santo plantations.

3.4 *Psiloptera pardalis* (Castelnau et Gory, 1836)

Adults of this insect (Fig. 6C) has been reported as damaging eucalypt plantations in Paraná state (VELLOZO *et al.*, 1953).

3.5 *Lampetis cupreosparsa* (Lucas, 1859)

Adults of this insect has been reported by BERTI FILHO (1981) as eating leaves of *E. urophylla* and others in São Paulo plantations, but adults have also been collected in Minas Gerais state (KERREMANS, 1910).

3.6 *Lampetis dives* (Germar, 1824)

Adults of this insect has been reported by BERTI FILHO (1981) as a pest of eucalypt leaves in São Paulo plantations, but they have also been collected in Rio de Janeiro state (KERREMANS, 1910).

3.7 *Lampetis doncheri* (Gory, 1840)

This species is very dark bronze and shiny; adults have been reported by BERTI FILHO (1981) as eating leaves of *E. urophylla* and *C. citriodora* in Espírito Santo plantations.

3.8 *Lampetis instabilis* (Castelnau et Gory, 1836)

Adults of this insect has been reported by BERTI FILHO (1981) as attacking leaves of *E. grandis* in Espírito Santo plantations.

3.9 *Lampetis solieri* (Lucas, 1859)

Adult of this insect has been reported by ANDRADE (1961) as attacking shoots and soft stems in young plantations of *E. robusta* and *C. citriodora* in São Paulo state. It has also been collected in Mato Grosso state (KERREMANS, 1910).

4.0 Curculionoidea (Weevils)

As leaf feeders, weevils differ from other groups of leaf-eating beetles due to the presence of a rostrum and geniculate-clavate antennae inserted in the middle of the rostrum. Buccal parts are in the apical part of the rostrum, and wings become obsolete in many leaf-eating species; thus very many of them are flightless. The most important weevils in the Brazilian eucalypt plantations are the "Australian Snout Weevils" *Gonipterus gibberus* and *Gonipterus scutellatus*. They are not native insects in Brazil and they are very important forest pests in Australia, homeland of the eucalypt.

Native weevils have been recorded as pests in Brazilian eucalypt plantations (BERTI FILHO, 1981; SILVA *et al.*, 1968; ANDRADE, 1961), and include the following: *Asynonychus cervinus*, *Naupactus longimanus*, *xanthographus*, *Naupactus bipes*, *condecoratus*, *elegans*, *Lasiopus cilipes*, *Miremorphus eucalypti*, *Phaops adamantina*, *Rhigus tribuloides*, *Cyphus luridus*, *Heilipus fallax*, *Hoplopactus injucundus*, and *Hypsonotus sp.*

4.1 *Gonipterus scutellatus* Gyllenhal, 1833 and *G. gibberus* (Boisduval, 1835) (Gonipterinae)

The identity of these weevils in Brazil has been controversial since 1926, after they had been discovered in Argentina (MARELLI, 1928; VIDAL, 1955; FREITAS, 1979). *G. gibberus* was made as synonym of *G. scutellatus* by ZIMMERMAN (1991), but the existence of both species in Australia was previously recognized. These two species are similar to the point of confusion, but the number and arrangement of eggs in the egg case, colour of the larvae, pupae and adults can be differentiated by morphometric measurements in all phases. Based on the male/female genitalia and larvae morphology, both *Gonipterus* species are, nowadays, living on eucalypts in Brazilian plantations (ROSADO-NETO & MARQUES, 1996). However, this Coleoptera genus still needs taxonomic revision (ROSADO-NETO, G. H., personal communication). In Brazil, *G. scutellatus* and *G. gibberus* (Fig. 7A) are known as "Australian Eucalypt-weevil" and they are the only introduced leaf-eating beetles attacking eucalypt plantations.

In 1954, adults of these insects were discovered in the Rio Grande do Sul state, where they caused serious damage in eucalypt plantations (KOBBER, 1955). From that region, these beetles have spread throughout the Santa Catarina, Paraná and São Paulo states, where they have been reported as eucalypt pests (FREITAS, 1979; FENILLI, 1982, BERTI FILHO *et al.*, 1992). It is expected that they will spread to Minas Gerais' biggest plantations, where they will constitute a serious problem for large plantations owners.

A valuable contribution to the taxonomy and biology of *G. gibberus* was made by FREITAS (1979), who first recorded the presence of *Gonipterus scutellatus* in Brazil, where it was formerly reported as *G. platensis*. A description of immature forms of this species was provided by ROSADO-NETO and FREITAS (1982). According to FREITAS (1979), male beetles of *G. gibberus* are 6.7 to 7.8 mm long and females are 7.7 to 8.8 mm. General colour ranges from brown to dark brown. The elytra are convex and covered with dark infuscated lines of dots on the fore parts and white bands directed down the sides of the body, forming a characteristic inverted "V" letter.

G. gibberus females lays 1 to 6 eggs on the eucalypt leaves, which are protected in a faecal case. For *G. scutellatus*, the case contains 10 to 15 eggs. Larvae are without ocelli, their body is curved and greenish in colour, sometimes with dorsal and lateral yellowish stripes. The expelled faeces are filamentous. At the end of the fourth instar, the larvae loses the ability to affix itself to the foliar surface and falls to the ground, where it burrows in a suitable place to a depth of 1 to 5 cm, and builds a pupal chamber. After an average period of 31 days, the adult emerges from the point of entry of the larva. After flying up from the soil, adults disperse evenly in the tree canopy, where they feed on leaves, with preference for young leaves rather than old leaves. Adults feign death and drop to the ground when disturbed, or grasp a twig so firmly that removing it may result in tearing off its legs.

G. gibberus beetles appear in the spring after passing the winter as mated females. Egg clusters and larvae coincide with the appearance of new shoots on the tree, mainly in September and October. After hatching, the larva feeds directly on unexpanded leaves, making long hollows on the leaf surface; adults feed mainly on newly expanded leaves (Fig. 7B), which results in typical scalloped shapes on the leaves. Each *G. gibberus* insect consumes more than 400 mg of fresh *E. saligna* leaves during the larval phase (FREITAS, 1979). During the last instar, each larvae consumes more than 60% of the total larval food intake (FREITAS, 1979), meaning that the greatest part of damage is caused by developed larvae. Adults can survive for eight months before releasing the first egg batches, and females spend about one more month laying eggs on eucalypt trees. About two months after oviposition, females die. Only one generation per year was reported by FREITAS (1991), but two generations were reported by KOBBER (1955).

In Brazil, different *Eucalyptus* species are hosts of *G. gibberus* (LUBIANCA, 1955). According to this author, *E. viminalis*, *E. rostrata*, *E. robusta* and *E. globulus* were seriously attacked, but highest numbers of beetles were reported attacking the last three species. Besides the species mentioned, *E. tereticornis* was reported as a host by SILVA *et al.* (1968) and *E. saligna* var. *protusa* was added by FREITAS (1979).

4.2 *Asynonychus cervinus* (Boheman, 1840) (Brachyderinae)

Weevils in the *Asynonychus* genus are polyphagous insects and their larvae live underground. Adults emerge when the ground is wetted by the first rains in the warm period of the year. The weevils do not fly and are mostly active at night.

Asynonychus cervinus, or “Fuller’s Rose Weevil” (Fig. 8), is a worldwide introduced pest in many crops. It has been reported as a pest in Lauraceae, Orchidaceae, Palmaceae, Solanaceae, Graminae, Vitaceae, and many other Brazilian native and cultivated plants, including eucalypts (SILVA *et al.*, 1968). It has been reported in São Paulo, Rio de Janeiro, Rio Grande do Sul and Santa Catarina states. According to GALLO *et al.* (1988), the adult of the Fuller’s Rose Weevil is 10 mm in length, 5 mm wide, and brown to grey in colour. The tibial apex has a spine on the internal margin, perpendicular to the tibial axis. The abdomen is completely covered by the elytra. As is the case with the prothorax, it is glabrous. Normally, hind wings are well developed, but the forewings are obsolete. During the day, adults remain hidden, but they feed upon leaves at night. Larvae of “Fuller’s Rose Weevil” are hypognathous, with a curved body and being whitish in colour. They have no developed thoracic legs or eyes. The antennae are reduced. When fully developed, the larva constructs a shelter where it is protected until emergence as an adult.

4.3 *Naupactus longimanus* (Fabricius, 1775) (Brachyderinae)

Weevils in the *Naupactus* genus are known popularly as “Carneirinho” (Little Sheep) in Brazil. These weevils are highly polyphagous pests, being able to feed on a very wide range of plant species, resulting in variable damage. The centre of origin of *Naupactus* species is South America, and dozens of species live on Brazilian native plants. According to SILVA *et al.* (1968), adults of 17 species were reported as pests of Malvaceae, Musaceae, Rosaceae, Solanaceae, Rubiaceae, Rutaceae, Graminae, Fabaceae, Vitaceae, Sterculiaceae, Lauraceae, and other Brazilian native and cultivated plants.

Naupactus longimanus (Fig. 9) is a very common weevil on Brazilian plants, where adults attacks native trees in the *Inga* genus, as well as cultivated crops such as grapes and oranges

(SILVA *et al.*, 1968). These authors reported adults of *N. longimanus* as a pest of *C. citriodora*, *E. saligna* and other eucalypts in the Rio de Janeiro and Minas Gerais states.

4.4 *Naupactus xanthographus* (Germar, 1824) (Brachyderinae)

This is called the “Fruit Tree Weevil”. It is a brown-grey to the dark grey beetle, with small coloured spots (MARICONI, 1956). Males are, in general, lighter coloured and smaller than the female, and both vary from 4 to 18 mm long, so they are frequently unnoticed on plants. The “Fruit Tree Weevil” can readily be captured due to its habit of freezing when disturbed. The weevil prefers to rest in the branches rather than on leaves and, at night, they leave their hiding place and damage the eucalypts leaves.

Adults of this weevil were reported attacking leaves and sprouts of eucalypt plantations, and also leaves of other Myrtaceae and Solanaceae crops in the Rio Grande do Sul, Paraná and São Paulo states (SILVA *et al.*, 1968). Its economic importance has not been properly evaluated. Adults appear in the eucalypt plantations from December to March and their damage is very characteristic, because adult beetles consume intercalated parts of the foliar limb, from the leaf edge inwards.

4.5 *Naupactus bipes* (Germar, 1824) (Brachyderinae)

Adults of *N. bipes* attack orange and grape crops, and also Brazilian native trees in the genus *Inga*, in the Rio de Janeiro and Paraná states (BONDAR, 1924; VELLOZO *et al.*, 1953). However, adults of this beetle were reported by BERTI FILHO (1981) as a frequent problem in eucalypt plantations in the Mato Grosso state. There, adults of *N. bipes* were reported attacking leaves of *E. grandis* and *E. urophylla*.

4.6 *Naupactus condecoratus* (Boheman, 1840) (Brachyderinae)

This species was reported as a eucalypt pest in the Minas Gerais state. There, adult beetles attacked *E. saligna* leaves (SILVA *et al.*, 1968).

4.7 *Naupactus elegans* Lucas, 1859 (Brachyderinae)

This species was reported by BERTI FILHO (1981) as a frequent problem in eucalypt plantations Mato Grosso state, where adults attack leaves of *E. saligna*, *E. urophylla* and *E. grandis* trees.

4.8 *Lasiopus cilipes* (Sahlberg, 1823) (Leptosinae)

This weevil is known as a cocoa leaf pest in the Bahia plantations (BONDAR, 1939; LIMA, 1956; SILVA *et al.*, 1968), but BERTI FILHO (1981) recorded it on leaves of *C. citriodora* in the Espírito Santo plantations.

4.9 *Miremorphus eucalypti* Bondar, 1950 (Dinomorphinae)

This weevil species is known only in eucalypt trees. Adults were reported as attacking eucalypt shoots and leaves in the Goiás plantations (BONDAR, 1950; SILVA *et al.*, 1968). According to LIMA (1956), the true taxonomic name of this insect is doubtful.

4.10 *Phaops adamantina* Germar, 1824 (Otiorrhynchinae)

Many *Phaops* species were reported by SILVA *et al.* (1968) as being associated with Fabaceae, Vitaceae, Rutaceae and eucalypts. *Phaops thumbergi* Dalman 1823 was reported on eucalypt flowers (PINHEIRO, 1962), but BERTI FILHO (1981) reported *P. adamantina* on leaves of eucalypts in Espírito Santo plantations.

4.11 *Rhigus tribuloides* Pallas, 1781 (Leptosinae)

Weevils in this genus were reported by BONDAR (1924) as vineyard pests in the Rio de Janeiro state. However, BERTI FILHO (1981) reported *R. tribuloides* as attacking eucalypt leaves in Espírito Santo plantations.

4.12 *Cyphus luridus* Boheman, 1840 (Brachyderinae)

This weevil was reported on eucalypt leaves in São Paulo plantations (PINHEIRO, 1962) in his contribution to the inventory of eucalypt insects in Brazil. BERTI FILHO (1981) collected *Cyphus* sp. on *E. alba* leaves in Espírito Santo plantations.

4.13 *Heilipus fallax* Boheman, 1843 (Hylobiinae)

This weevil was reported as a pest of *E. saligna* leaves in São Paulo plantations (BERTI FILHO, 1981).

4.14 *Hoplopactus injucundus* (Boheman, 1833) (Brachyderinae)

This weevil was reported as a eucalypt leaf-eater in Rio de Janeiro plantations (SILVA *et al.*, 1968).

4.15 *Hypsonotus* sp. (Leptosinae)

Many species in this genus are known as leaf pests of Sterculiaceae, Vitaceae and Cecropiaceae (SILVA *et al.*, 1968). One undetermined species was reported as a leaf-eating weevil on *E. saligna* in São Paulo plantations and on *E. paniculata* in the Minas Gerais plantations (BERTI FILHO, 1981).

5.0 Scarabaeidae (Spring Beetles)

These leaf-eating beetles are known popularly in Brazil as "Scarab Beetles", and the most important species recorded as a leaf feeder in eucalypt plantations is *Bolax flavolineata*. Other species of Scarabaeidae have been recorded as harmful to eucalypts and, according to ANDRADE (1961), SILVA *et al.* (1968) and BERTI FILHO (1981), they are *Geniates barbatus*, *Leucothyreus niveicollis*, and *Philoclaenia tricolorata*.

5.1 *Bolax flavolineata* (Mannerheim, 1829)

The "Brown Scarab Beetle", as it is popularly known in Brazil, measures 11 to 15 mm in length and 7 to 9 mm in width (Fig. 10A). This scarab pest occurs in practically all Brazilian States, but is quite rare in the Southern region. According to SILVA *et al.* (1968), it commonly occurs in the Southern region, particularly, São Paulo, Minas Gerais, and Rio de Janeiro. This leaf eating beetle attacks leaves of *E. saligna*, *E. alba* and *C. citriodora*. It also attacks leaves of the native myrtaceous *Psidium guajava*, *P. guineense* and *Myrciaria jaboticaba*, and also of avocado *Persea americana*, Brazilian Rosewood *Dalbergia nigra*, *Eryobotria japonica*, *Moquilea tomentosa*, *Prunus* spp., *Inga* sp., *Ficus* sp., *Chorisia* sp., and other plants such as cotton, peanut, potato, sugar-cane, grapes, banana, bean, pear, rose, peach, apple and corn.

According to MARICONI (1956) and GALLO *et al.* (1988), adults are brownish, but the head and the pronotum are dark brown. The elytra are of a medium brown-yellow colour, with yellow ridges longitudinally. The ventral part of the body is brown-dark with white-yellowish

pubescence. Eggs are released in the ground where larvae hatch, develop and form pupae. The larvae live in the ground, where they feed on roots and pupate. Diapause can occur.

At the time of the occurrence of the first rains, normally September to November, adults of the “Brown Scarab” swarm in large numbers to feed on leaves of many trees (MARICONI, 1956). They are nocturnal, and during the day remain hidden under bark on trees, in cracks or in other hiding places. During the day, the movements of this scarab are very slow; except when captured they do not move much at all. Although having nocturnal habits, the insect has been found feeding at sunrise. The adult of “Brown Scarab” eats mainly leaves (Fig. 10B), but it also attacks sprouts and flowers. Damage occurs firstly at the top of the tree and then systematically in foliage from top to bottom of the tree canopy. The beetles eat the whole leaf, but not strong veins.

In the South of Minas Gerais state, outbreaks of “Brown Scarab” occurred in November 1989, November 1990, and December 1991, when beetles appeared in huge numbers on eucalypt trees. In this case, the scarab was attacking 2-year-old *E. urophylla*, *E. torelliana* and *E. saligna* plantations, where the beetles ate mainly the old foliage in the upper part of the tree canopy. In this case, *C. citriodora* trees younger than one year were severely defoliated by these scarabs. Recently, an outbreak of “Brown Scarab” occurred in a 1-year-old plantation of hybrid between *E. urophylla* X *E. grandis*, in Andrelândia county, Minas Gerais state. It began in early November 2002 and finished in January 2003. About 100 hectares of eucalypt plantation were affected by this scarab beetle.

5.2 *Geniates barbatus* Kirby, 1818

According to SILVA *et al.* (1968), this scarab pest occurs in the Southern and South region in Brazil (Fig. 11A). The insect attacks leaves of *E. robusta*, *E. tereticornis* and one undetermined eucalypt. It also attacks leaves of the native myrtaceous *Psidium guajava* and *Eugenia pitanga*, and also *Mangifera indica*, *Cocus nucifera*, *Anacardium occidentale*, *Terminalia* sp., *Rosa* spp., and other plants such as tea tree (*Ilex paraguariensis*).

5.3 *Leucothyreus niveicollis* Laporte, 1840

This scarab pest (Fig. 11B) was detected in São Paulo state, where it was observed eating *E. saligna* leaves (ANDRADE, 1961), but its occurrence has been detected in Rio de Janeiro as well. Other *Leucothyreus* species have been recorded from almost all states in Brazil.

5.4 *Philoclaenia tricostata* Burmeister, 1855

This scarab has been observed eating leaves of *E. robusta* and *E. tereticornis* trees in the Rio de Janeiro plantations (ANDRADE, 1961), but it may also occur in Minas Gerais and São Paulo states, where *Philoclaenia setifera* and *Philoclaenia virescens* have also been detected on different plants.

6.0 Coccinellidae (Ladybird Beetles)

Most coccinellids in Brazil are beneficial as both adults and larvae, feeding primarily on aphids. They also feed on mites, small insects, and insect eggs. The exceptions are the squash beetles from the *Epilachna* genus, which have phytophagous behaviour, and cause damage mainly on leaves of cucurbit and solanaceous plants (COSTA *et al.*, 1988). They are vectors of plant viruses, as well (FIELD *et al.*, 1994). This is a large group of leaf beetles, which includes at least six species which can be serious pests in crops. According to LIMA (1953), the most common Brazilian species of “Ladybird Beetles” are *E. clandestina* Mulsant, 1850, *E. cacica* (Guérin, 1842), *E. paenulata* (Germar, 1824) and *E. marginella* (Fabricius, 1787).

6.1 *Epilachna clandestina* Mulsant, 1850 (Epilachninae)

E. clandestina is a species in which both larvae and adults attack eucalypt leaves in Brazilian plantations (SILVA *et al.*, 1968). It is known popularly as “Squash Beaf Beetle”, and both larvae and adult of this beetle attack the pumpkin, watermelon, cantaloupe, cucumber, and squash. This insect was reported in São Paulo, Rio de Janeiro and Rio Grande do Sul states. FONSECA and AUTUORI (1931) and MARANHÃO (1939) provide more details about this species. The adult measures around 8.5 mm in length and has an oval and pubescent body. The beetle colour is dark ventrally and brown dorsally. Internal and external margins of the elytra are yellowish. The egg is elliptical and yellow, 1 mm in length and 4 mm in width. The larval body is covered with six black, erect setae and six series of long and branched setae. The pupa is yellow, with dark spots, and measures around 8 mm in length and 7 mm in width. The adult’s head is more or less hidden by the prothorax. The antennae can be retracted to under the prothorax, and be inserted between the eyes. Four tarsi are present; the tarsal structure is pseudo-trimerous, the second tarsomere being concealed within the lobe of the preceding tarsomere, so that only three segments are distinctly visible. The tarsal claws are denticulate at the bases. The elytra cover the abdomen, which have five free sternites. The larva has long legs and moves in the same manner as the adult.

The beetle lives around the epigeous part of the plant, where it lays its eggs. Larvae pupate and then the adults, when they emerge, fly freely. When touched, they bend the antennae and legs and, as if dead, they free-fall to the ground. The larvae and adults attack leaves, reducing them to a skeleton. They feed exclusively on leaf parenchyma, leaving only intact veins. That damage is very characteristic, being enough to identify the nature of the beetle causing the damage. After attack, the branch becomes yellow and wilts.

E. cacica, which is broadly known as “Squash Beetle”, was mentioned by GALLO *et al.* (1988) as one of the most important leaf beetle pests in the cucurbitaceous crops. PRECETTI *et al.* (1977) provides more biological and economic details about this pest.

Epilachna vigintioctopunctata, a worldwide pest, was found on wild cucurbit plants near Curitiba, Paraná, Brazil, in October, 1990. This is the first record of this species from the Western Hemisphere (SCHRODER *et al.*, 1993). New records since that discovery are already available for Paraná, and Santa Catarina on food plants of agricultural importance. Another famous pest, the “Mexican Bean Beetle” *Epilachna varivestis*, a close relative of the squash beetle, was studied by ARAÚJO *et al.* (1990) in the Brazilian Federal District.

Other *Epilachna* species are not well known, but they vary in colour and may become pests in the future.

7.0 Other Leaf-Eating Beetles

Other beetles have been reported by BERTI FILHO (1981) and by SILVA *et al.* (1968) as eucalypt leaf feeders in Brazilian plantations, but they require more accurate observations to be considered as eucalypt pests. Those beetles are *Colaspis rustica* (Boheman, 1859) (Chrysomelidae) on *E. salignai* and *E. alba*; *Doryphora dilaticollis* Stal (Chrysomelidae); *Callipogon luctuosum* (Schoenherr, 1817) (Cerambycidae) on *E. salignai*, *Stegotes sanguinicollis* Germar, 1824 (Curculionidae) on *E. saligna*, *Lydamis variegatus* Casey, 1922 (Curculionidae); and *Phaedropus* sp. (Curculionidae). Besides these beetles, *Charidotis marginella* (Fabricius 1775) (Cassidinae) was found on leaves of *E. saligna* in São Paulo plantations, but no damage was reported (ANDRADE, 1961). *Psiloptera hirtomaculata* Herbst, 1801 (Buprestidae) was found on *E. saligna* by ANDRADE (1961) in the São Paulo plantations. Additionally, this author reported *Cymatobaris impressifrons* Boheman, 1836 (Baridinae) on eucalypt leaves in the São Paulo plantations but, according to LIMA (1956), larvae of *C. impressifrons* are gall forming insects in native *Vernonia polyanthes* (Asteraceae) trunks.

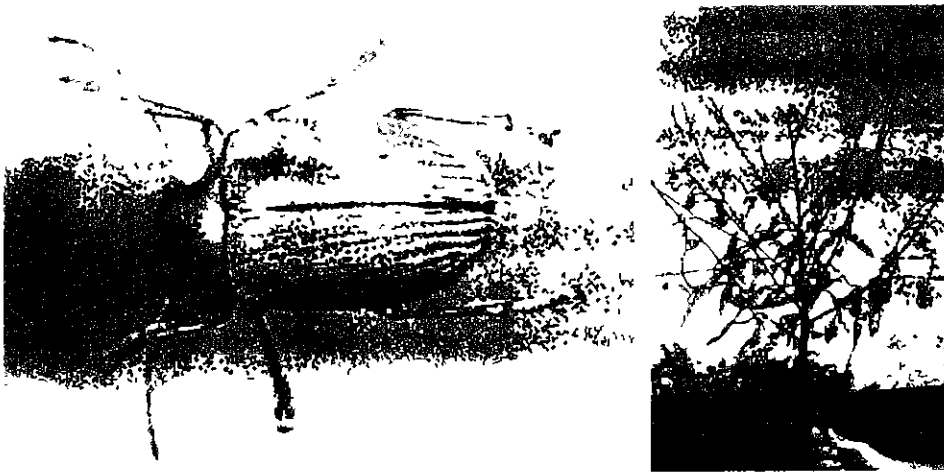


Figure 1. Dorsal view of *Costalimaita ferruginea* (A) and damage caused by adults to the canopy of 3-month-old eucalypt (B)

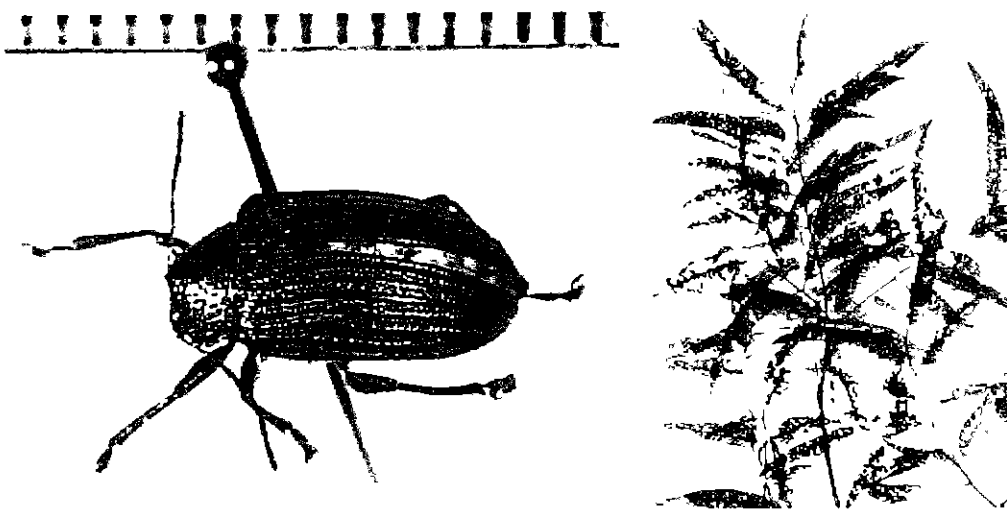


Figure 2. Lateral view of *Sternocolaspis quatuordecimcostata* adult (A) and damage to *Corymbia citriodora* leaves (B)

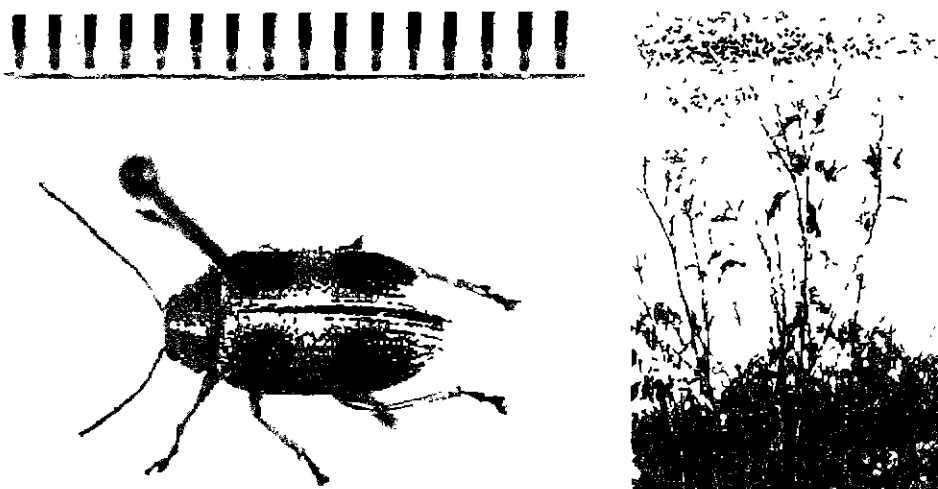


Figure 3. Dorsal view of *Metaxyonycha angustata* adult (A) and damage in the upper canopy of (B) *Eucalyptus grandis* one-year-old

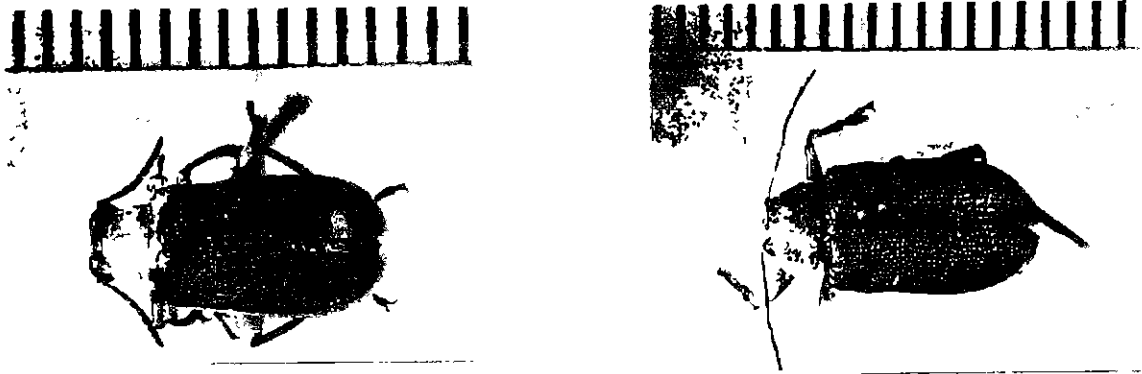


Figure 4. Dorsal view of *Agathomerus sellatus* (A) and *Cacoscelis marginata* (B)

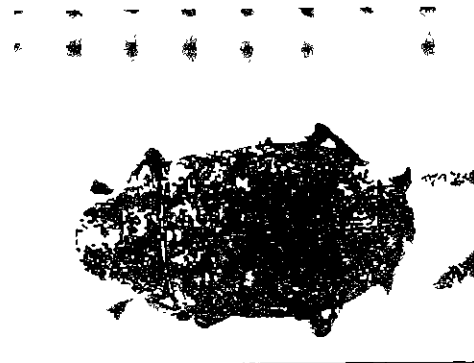


Figure 5. Dorsal view of *Myochrous armatus* adult



Figure 6. *Lampetis nigerrima* adult (A), its damage (B) and *Lampetis instabilis* (C)



Figure 7. *Gonipterus gibberus* adult (A) and its damage (B)

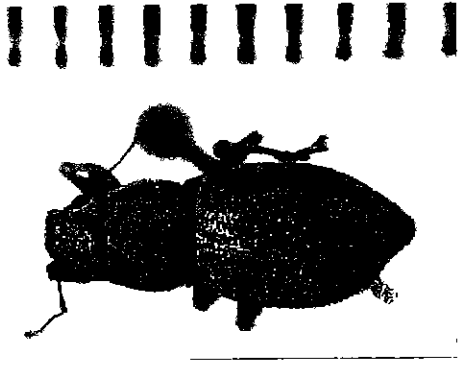


Figure 8. *Asynonychus cervinus* adult

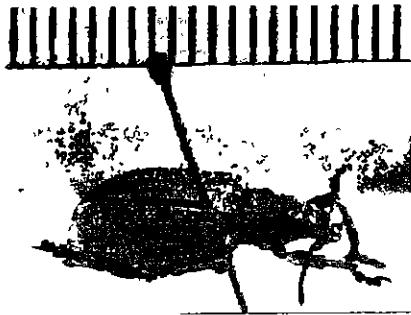


Figure 9. *Naupactus longimanus* adult

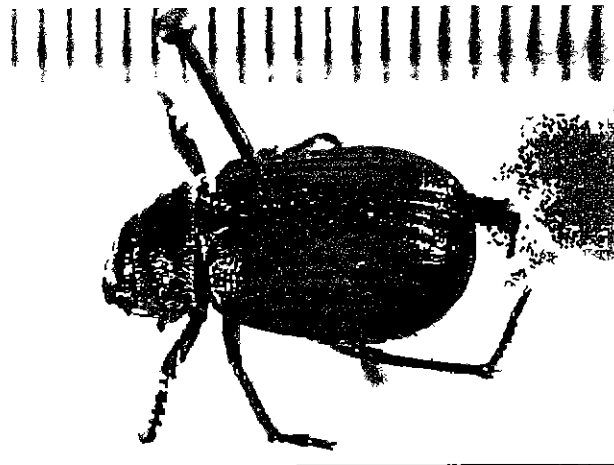


Figure 10. *Bolax flavolineata* adult (A) and its damage (B)

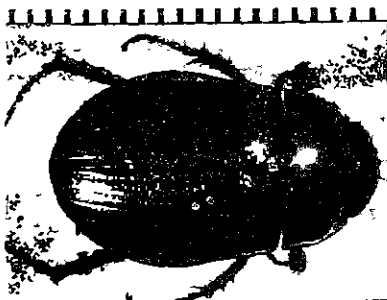


Figure 11. *Geniates barbatus* adult (A) and *Leucothyreus niveicollis* adult (B)

8.0 Integrated Pest Management

There is great concern about the ecological effects of eucalypt plantations. Because there is a low diversity of herbivores feeding on the eucalypt species, this means that other species such as predators are scarce (RIVERA & CARBONE, 2000). Tree plantations are an investment to produce wood for daily goods and industry, as is the situation when we grow wheat, potato, rice, bean, soy, and so many other monocultures in the world. Plants used in these crops are almost always exotic and cultivated as monocultures, which always results on less herbivore biodiversity. Maybe such concern is due to our wrong way of thinking of tree or forest plantations. We tend to confuse them with land reforestation projects, land rehabilitation activities or, perhaps, soil recovery programs. These forest plantations should be managed in a different way because they target an eroded place, a mine site, a biological reserve, public parks, or abandoned lands, where the main objective is to restore the original biodiversity. In such cases, native trees must be used in an ecological model to permit the restoration of the original vegetation and, then, the original faunal biodiversity.

As a monoculture, eucalypt plantations are subject to pest problems and, where substantial damage occurs, control measures should be improved to avoid economic losses and the consequent failure of the business. We need control measures in order to prevent and to cure pest problems. The best way, therefore, is selecting and developing different techniques that must be developed into an integrated program, which is ecologically adequate.

The management of leaf-eating beetles is hard because all species have larvae living in the ground and feeding on the roots of plants that may not be those that are attacked by adult beetles. The exceptions are the "Australian Snout Weevils", where both larvae and adults feed on leaves. The population control of insects in this group includes prevention techniques such as resistant hosts and cultural treatments that favour fast growth and compensation for the damage caused by insect pests.

Certainly, one of the best options for a program of eucalypt pest management is one where resistant trees can live together with insects, just as they live with many other organisms in a forest ecosystem, with reciprocal benefits. RIVERA and CARBONE (2000) have stated that biological control of leaf beetles is desirable but, where it is not effective, the most appropriate alternative should be the use of insect-resistant eucalypts. ANJOS (1992) observed that large numbers of "Eucalypt Yellow Beetle" on older and bigger eucalypt trees did not cause any concern to the forest managers, because those trees were tolerant. However, such a situation in the young plantations was extremely uncomfortable due to the possibility that chemical insecticides would have to be applied or seedlings replaced. Eucalypt susceptibility to attack by *C.*

ferruginea was evaluated by ANJOS and BERTI FILHO (1998) in experimental plantations of 36 eucalypt species. Severe damage was focused on the base of the leaves, just after a severe occurrence of this pest. As result, they found 8.33% of those eucalypts could be regarded as “non-favoured” species (*E. camaldulensis*, *E. microcorys* and *E. tereticornis*), and therefore, resistant to the beetle attacks. Among the remaining eucalypt species, 83.34% were classified as “favoured”, but only *E. torelliana* and *C. maculata* were revealed as “highly favoured”. In the case of the “Limeira Beetle”, *C. citriodora* is preferred, but the insect hardly attacks the branches of *E. alba*; *E. saligna* is slightly attacked and *E. maideni* appears to be immune against this leaf beetle (ORLANDO *et al.*, 1954). These results open up possibilities and encourage the use of resistant eucalypts in the integrated management system for eucalypt leaf beetles in Brazilian commercial plantations. In Argentina, *E. globulus*, *E. viminalis*, *E. rostrata*, *E. robusta*, *E. amygdalina*, *E. citriodora* and *E. saligna*, in a decreasing order of preference, are eucalypts attacked by the “Australian Snout Weevil” (MARELLI, 1928). In Spain, where *G. scutellatus* was introduced in 1991, diet has a significant effect on larval development and survival but, under wild conditions, adults showed a marked preference for *E. globulus*, *E. longifolia*, *E. grandis*, and *E. propinqua* and avoided *E. cornuta*, *E. fastigata*, *E. ficifolia*, *E. niphoploia*, *E. obliqua* and *E. amigdalina* (RIVERA & CARBONE, 2000). In South Africa, *E. viminalis* begins to be attacked when trees are about two years old but, by three years of age, attacks were enough to cause a growth loss over 50% on susceptible varieties when compared with resistant strains (RICHARDSON & MEAKINS, 1986).

An additional way to use plant resistance is through the use of trap plants to divert leaf beetle attacks away from susceptible trees. In the case of the Brazilian “Eucalypt Yellow Beetle”, we have developed a system of leaving stump sprouts at least two months before the appearance of the adults, taking them off only after the beetle population decreases. Thus, beetles can feed on these sprouts, which are preferable to the seedlings planted among old tree stumps. This control technique has produced good results in all cases where population densities were not high enough to consume the foliage of sprouts and saplings. The same technique has produced good results for “Jewel Beetle” management as well.

In the case of Jewel beetles, the manually picking of insects from young plantations is the technique most used in all affected plantations. However this technique demands large amounts of labour and needs to be repeated from one to five times to reduce the damage caused by these buprestids.

There is no commercial technique for biological control of the “Eucalypt Yellow Beetle” in Brazil. Although ANJOS *et al.* (1990) and ANJOS (1992) referred to the occurrence of predators and pathogenic fungi, none of these biological agents can be used efficiently against the adult phase, because the beetles swarm so quickly and in such huge numbers that they are capable

of causing enormous damage in just a few days. Control measures against this pest using pathogenic fungi or bacteria have been hindered by the fact that Eumolpinae larvae feed in plant roots, which are not attacked by adult beetles (IGLESIAS, 1916). However, both species of Australian Snout Weevil are controlled by the wasp *Anaphes nitens* (Girault) (Hymenoptera: Mymaridae) in Brazil. The wasp was brought from Australia to South Africa and then was introduced into Argentina, from whence it accompanied Australian snout weevil into the Brazilian eucalypt plantations. Unfortunately, there is no report about this wasp's efficiency in the Brazilian forest plantations.

Overall, an efficient system to monitor populations of leaf-eating beetles and their damage must be devised for all eucalypt plantations in order to identify the most heavily infested places, the most susceptible tree varieties, the most susceptible age, etc. According to ANJOS (1992), the larvae of *Costalimaita ferruginea* develop in neighboring sugar-cane crops and pasturelands, which are always large in extent. Thus, such places are critical points for frequent monitoring, and plantations here may be attacked more easily than others located further away. The use of periodic evaluation should forecast the beginning of outbreaks and flag the need for adequate measures to combat them. Although MARICONI and SOUBIHE SOBRINHO (1961) considered control to be "easy", ANJOS *et al.* (1990) verified that chemical insecticides were the only measure capable of Yellow Beetle control. An economic evaluation of the damage and risks allows us to obtain information of great importance for decision-making regarding whether to intervene or not, as well as the appropriate shape of intervention and the best control method for each situation. We have developed a software program to enable managers to make complex decisions. It is called "CMB – Monitored System for Leaf Beetle Control" and is available free from the senior author.

Despite multiple possibilities, Brazilian eucalypt growers have preferred chemical treatment in almost 50% of occurrences of "Yellow Eucalypt Beetle" (ANJOS, 1992), but this number is reduced to about 10% in places where a good monitoring system is in operation. Chemical insecticides have been the only alternative, given the almost complete absence of natural enemies and the lack of studies aimed at biological control (ANJOS, 1992). According to this author, the use of insecticides in eucalypt plantations, despite their efficiency, can result in the necessity for new applications due to adult emergence from larval sites. This creates the necessity for more chemical treatments if the first treatment is administered too early. If chemical treatment cannot be avoided, it must be limited to very intense infestations, new plantations, and where it is justifiable, as an economic, ecological, and social strategy. Chemical insecticides must be applied in moderate or low volume spray applications, avoiding the hottest periods of the day. The management of this group of pests in open nurseries may include a lot of chemical interventions, so it is necessary to plan well to avoid environmental problems. In the case of the Australian

Eucalypt Weevil, chemical insecticide use may destroy the wasp parasites and cause environmental disruption, if used in the wrong way.

Finally, we conclude that the leaf-eating beetles in Brazil pose great challenges for Brazilian entomologists because, not only are many of them very significant economic pests, but little information is available on their biology and control options. Therefore, it is necessary for forest managers and the eucalypt industry to get involved in a whole research program to generate the necessary scientific knowledge for establishing monitoring systems, and for developing prevention techniques and control methods.

9.0 Acknowledgements

We thank the Votorantim Celulose e Papel (VCP) for support with this work, and also the many Brazilian forestry companies for permitting work to occur in their eucalypt plantations. We thank Brian Heterick (Curtin University of Technology) for manuscript revision, Maurizio Gigli (Rome, Italy) for Buprestidae identification, and Fernando Vaz-de-Mello" for the scarab photos 11A and 11B. This work would not be possible without the support from CAPES (Brazil) and the C. Y. O'Connor Fellowship scheme (Curtin University of Technology). We are grateful to both of these institutions.

10.0 References

- Alemán, M. (1991). Registro de *Costalimaita ferruginea proxima* Klug (Coleoptera: Chrysomelidae) atacando eucaliptos (Myrtaceae) experimentales en El Edo. Bolivar. *Boletín de Entomología Venezolana* 6: 26.
- Andrade, E. N. (1909). Os insetos nocivos ao eucalyptus. *Entomologista Brasileiro* 2:141-145.
- Andrade, E. N. (1961). *O Eucalipto*. Cia. Paulista de Estradas de Ferro, São Paulo.
- Anjos, N. (1992). Taxonomia, ciclo de vida e dinâmica populacional de *Costalimaita ferruginea* (Fabr., 1801) (Coleoptera: Chrysomelidae), praga de *Eucalyptus* spp. (Myrtaceae). *PhD Thesis*, ESAL/USP, Piracicaba.
- Anjos, N. and Berti Filho, E. (1998). Preferência hospedeira de *Costalimaita ferruginea* (Fabr. 1801) (Coleoptera: Chrysomelidae) em *Eucalyptus* spp. Actas del Congreso Internacional de Plagas Forestales. *Proceedings of the International Forest Insect Workshop*. Pucon, Chile. pp.425-430.
- Anjos, N., Berti Filho, E. and Alves, S. B. (1990). Ocorrência de *Beauveria* e *Metarhizium* em besouro amarelo dos eucaliptos. *Revista de Agricultura* 65:279-280.

- Anjos, N., Santos, G. P. and Zanuncio, J. C. (1987). A lagarta-parda, *Thyrintina arnobia* Stol., 1782 (Lepidoptera: Geometridae) desfolhadora de eucaliptos. *Boletim Técnico de EPAMIG*, Belo Horizonte, no.25 56pp.
- Araújo, A. C. G., Oliveira, S. F. and Kitajima, E. W. (1990). Gastro-endocrine, APUD-like cells in the digestive epithelium of some Coleoptera. *Microscopia-Electronica-y-Biologia-Celular* 14:19-34.
- Bechyné, J. (1953). Katalog der neotropischen Eumolpiden (Col. Phyloph. Chrysomeloidea). *Entomologische Arbeiten aus dem. Museum George Frey* 4: 26-303.
- Berti Filho, E. (1981). Insetos associados a plantações de espécies do gênero *Eucalyptus* nos Estados da Bahia, Espírito Santo, Mato Grosso do Sul, Minas Gerais e São Paulo. *Thesis Livre-Docência*, ESALQ/USPPiracicaba.
- Berti Filho, E. (1984). A entomofauna do eucalipto. In: *Seminário Sobre Atualidades e Perspectivas Florestais: Situação da Entomologia e da Patologia Florestal no Brasil*, 6: Curitiba, 1982. EMBRAPA-URPFCS, Curitiba. p.17-18.
- Berti Filho, E. (1985). Insects associated to eucalypt plantations in Brazil. In: *Protection of Forests in the Tropics/IUFRO WP, S2.07.0*. Curitiba, 1985. p.162-78.
- Berti Filho, E., Alves, S. B., Cerignoni, J. A. and Stape, J. L. (1992). Ocorrência de *Beauveria bassiana* (Bals.) Vuill. em adultos de *Gonipterus scutellatus* (Gyllenhal) (Coleoptera: Curculionidae). *Revista de Agricultura* 6:251-252.
- Bondar, G. (1924). Alguns curculionídeos nocivos à videira (*Vitis vinifera*). *Correio Agrícola* 2: 42-45.
- Bondar, G. (1939). Insetos daninhos e parasitas do cacau na Bahia. *Boletim Técnico do Instituto do Cacau* 5:1-112.
- Bondar, G. (1950). Notas entomológicas da Bahia. XXII. *Revista de Entomologia* 21:449-480.
- Booth, R. G., Cox, M. L. and Madge, R. B. (1990). In: *Guides to Insects of Importance to Man*, 3. *Coleoptera*. International Institute of Entomology, Cambridge.
- Costa, C., Vanin, A. S. and Casari-Chen, S. A. (1988). *Larvas de Coleoptera do Brasil*. USP. Museu de Zoologia, São Paulo.
- Elliott H. J., Ohmart, C. P. and Wylie, F. R. (1998). *Insect Pests of Australian Forests: Ecology and Management*. Inkata Press, Singapore.
- Fenilli, R. (1982). Primeiro registro de *Gonipterus platensis* Marelli, 1926 e *Gonipterus gibberus* (Boisduval, 1835) (Coleoptera, Curculionidae, Gonipterinae) no estado de Santa Catarina, Brasil. *Anais da Sociedade Entomológica do Brasil* 11:293-294.
- Field, T. K., Patterson, C. A., Gergerich, R. C. and Kim, K. S. (1994). Fate of viruses in bean leaves after deposition by *Epilachna varivestis*, a beetle vector of plant viruses. *Phytopathology* 84: 1346-1350.

- Fonseca, J. P. and Autuori, M. (1931). Contribuição para a biologia de *Solanophila clandestina* (Muls.) (Coleoptera: Coccinellidae). *Revista de Entomologia* 1: 219-224.
- Freitas, S. (1979). Contribuição ao estudo da morfologia e biologia de *Gonipterus gibberus* (Boisduval, 1835) (Coleoptera: Curculionidae) e levantamento de danos causados por esta espécie em eucaliptos dos arredores de Curitiba. *MSc Thesis*, UFPr, Curitiba.
- Freitas, S. (1991). Biologia de *Gonipterus gibberus* (Boisduval, 1835) (Coleoptera, Curculionidae): Uma praga de eucaliptos. *Anais da Sociedade Entomológica do Brasil* 20:339-344.
- Gallo, D., Nakano, O., Silveira-Neto, S., Carvalho, R. P. L., Batista, G. C., Berti Filho, E., Parra J. R. P., Zucchi, R. A., Alves, S. B and Vendramim, J. D. (1988). *Manual de Entomologia Agrícola*. Agronômica Ceres, São Paulo.
- IBGE- Fundação Instituto Brasileiro de Geografia e Estatística. (1981). *Silvicultura – Brasil – Grandes regiões – Unidades da federação – Mesorregiões – Microregiões homogêneas - Municípios*. Rio de Janeiro, v. 2.
- Iglesias, F. (1916). Insectos nocivos e úteis ao algodoeiro. *Boletim de Agricultura* 17:968-98.
- Junqueira, G. M. (1962). Nota sobre o "besouro amarelo dos eucaliptais". *O Biológico* 28:326-328.
- Kerremans, C. (1903). Coleoptera, Serricornia, Fam. Buprestidae, 2. In: Wytsman, P., (ed.). *Genera Insectorum*, 12 b: 49-112. Wytsman, Bruxelles.
- Kerremans, C. (1910). *Monographie des Buprestids, 5, Chalcophorini: Psilopterites*. Janssens, Bruxelles.
- Kober, E. (1955). Observações preliminares da ação de diversos inseticidas orgânicos de síntese, no controle ao *Gonipterus gibberus* Boisduvall, praga do eucalipto. *Agronomia Sulriograndense* 2:30-40.
- Kramer, P. J. and Kozlowski, T. T. (1972). *Fisiologia das árvores*. Fundação Calouste Gulbenkian, Lisboa.
- Lima, A. M. C. (1952). *Insetos do Brasil, Coleópteros, 1ª parte*, IBGE, Rio de Janeiro 7: (Série Didática, 9).
- Lima, A. M. C. (1953). *Insetos do Brasil, Coleópteros, 2ª parte*. IBGE, Rio de Janeiro 8: 323p. (Série Didática, 10).
- Lima, A. M. C. (1955). *Insetos do Brasil, Coleópteros, 3ª parte*, IBGE, Rio de Janeiro, 9: 289 p. (Série Didática, 11).
- Lima, A. M. C. (1956). *Insetos do Brasil, Coleópteros, 4ª parte*. IBGE, Rio de Janeiro, 10: 373 p. (Série Didática, 12).
- Link, D. and Costa, E. C. (1984). Alguns problemas fitossanitários em viveiros de essências florestais no Rio Grande do Sul. In: *Seminário Sobre Atualidades e Perspectivas Florestais*:

- Situação da Entomologia e da Patologia Florestal no Brasil*, 6. Curitiba, 1982. Anais... Curitiba, EMBRAPA-URPFCS. p.51-53.
- Lubianca, J. L. (1955). O *Gonipterus gibberus* Boisduval, como praga do eucalipto no Rio Grande do Sul. *A Granja* 11:54-57.
- Macedo, N. (1975). Estudo das principais pragas das ordens Lepidoptera e Coleoptera dos eucaliptais do Estado de São Paulo. *MSc Thesis*, ESALQ/USP, Piracicaba.
- Maranhão, Z. C. (1939). Pragas das curcubitáceas cultivadas. *Revista de Agricultura de Piracicaba* 17:371-388.
- Marelli, C. A. (1926). La plaga de los gorgojos de los eucaliptos. *Revista de la Sociedad Entomologica de Argentina* 1:14-22.
- Marelli, C. A. (1928). Estudio sobre una peste de los eucaliptos descubierta en la Argentina. *Memorias del Jardim Zoologico de La Plata* 3:51-183.
- Mariconi, F. A. M. (1956). Alguns besouros depredadores de eucaliptos na região de Piracicaba. *O Biológico* 22: 1-14.
- Mariconi, F. A. M. and Soubiê-Sobrinho, J. (1961). Contribuição para o conhecimento de alguns insetos que depredam a goiabeira (*Psidium guayava* L.). *Publicação Científica Instituto de Genética* 2:35-67.
- Mendes, J. E. P. (1999). Nível de dano e impacto do desfolhamento por *Costalimaita ferruginea* (Fabr.) (Coleoptera: Chrysomelidae) em *Eucalyptus grandis* Hill ex Maiden. *MSc Thesis*, UFV, Viçosa.
- Mendes, J. E. P., Anjos, N. and Camargo, F. R. A. (1998). Avaliação dos danos causados por *Costalimaita ferruginea* (Fabr.) (Coleoptera: Chrysomelidae) em reflorestamentos de eucaliptos. *Actas del Congreso Internacional de Plagas Forestales. Proceedings International Forest Insect Workshop*. Pucon, Chile. p.431-435.
- Oglobim, O. (1935). Nueva plaga de los eucaliptos (*Colaspoides vulgata* Léf.). in *Misiones. Register del Ministry of Agriculture, Buenos Aires* 10:255-256.
- Ohmart, C. P. and Edwards, P. B. (1991). Insect herbivory on eucalyptus. *Annual Review of Entomology* 36:637-657.
- Orlando, A., Mariconi, F. A. M. and Iba, S. (1954). O besouro-de-limeira: Praga de frutíferas, eucaliptos e algumas outras culturas. *O Biológico* 20:1-20.
- Pinheiro, J. V. 1954. Contribuição para o conhecimento de insetos nos eucaliptais no Brasil. In: *Congresso Florestal Brasileiro, Curitiba, 1953. Anais Curitiba, Instituto Nacional do Pinho*. 157-67.
- Pinheiro, J. V. (1962). Contribuição para o conhecimento de insetos nos eucaliptais no Brasil. *Anuário Brasileiro de Economia Florestal, Rio de Janeiro* 14:245-255.

- Precetti, A. A. C., Milanez, J. M., Parra, J.R.P. and Berti Filho, E. (1977). Biologia e prejuizos causados por *Epilachna cacica* (Guérin, 1842) em aboboreira (*Curcubita moschata* Duchesne). *Ecosistema* 2:23-27.
- Ribeiro, G. T. and Zanuncio, J. C. (2000). Occurrence of *Psiloptera* sp. (Coleoptera: Buprestidae) damaging plants of *Eucalyptus* spp., in the Northeast region of Bahia, Brazil. In: *XXI International Congress of Entomology, Forest Entomology*, Session 10, p.492. Foz do Iguassu, Brazil. 2000.Abstracts, Book 1. Londrina, Brazil, 664p.
- Richardson, K. F and Meakins, R. H. (1986). Inter and intra-specific variation in the susceptibility of eucalypts to the snout beetle *Gonipterus scutellatus* Gyll. (Coleoptera: Curculionidae). *South African Forest Journal* 139:21-31.
- Rivera, A. S. and Carbone, S. S. (2000). The effect of three species of *Eucalyptus* on growth and fecundity of the *Eucalyptus* snout beetle (*Gonipterus scutellatus*). *Forestry* 73:21-29.
- Rosado-Neto, G. H. and Freitas, S. (1982). Description of immature forms of the eucalyptus weevil *Gonipterus gibberus* Boisduval, 1835 (Coleoptera, Curculionidae). *Revista Brasileira de Biologia* 42:467-471.
- Rosado-Neto, G. H. and Marques, M. I. (1996). Características do adulto, genitália e formas imaturas de *Gonipterus gibberus* Boisduval e *G. scutellatus* Gyllenhal (Coleoptera, Curculionidae). *Revista Brasileira de Biologia* 13:77-90.
- Schroder, R. F. W., Athanas, M. M. and Pavan, C. (1993). *Epilachna vigintioctopunctata* (Coleoptera: Coccinellidae), new record for Western Hemisphere, with a review of host plants. *Entomological News* 104 :111-112.
- Silva, A. G. A., Gonçalves, C. R., Galvão, D. M., Gonçalves, A. J. L., Gomes, J., Silva, M. N. and Simoni, L. (1968). *Quarto Catálogo dos Insetos que Vivem nas Plantas do Brasil, Seus Parasitos e Predadores*. Part 2, Tomo1. Rio de Janeiro, Ministério da Agricultura.
- Speight, M. R. and Wylie, F. R. (2001). *Insect Pests in Tropical Forestry*. CABI Publishing, Wallingford. 307p.
- Vidal, S. J. A. (1955). Contribucion a la aclaracion definitiva del problema existente entre las especies "*Gonipterus gibberus*"Boisd, Y "*G. platensis*"Mar. *Notas del Museo La Plata (Zoologia)* 18:31-41.
- Vellozo, L. G. C., Nowacki, M. J. and Vernalha, M. M. (1953). Contribuição ao levantamento fitossanitário do Estado do Paraná. *Arquivos de Biologia e Tecnologia* 8:349-378.
- Zimmerman, E. C. 1991. *Australian Weevils (Coleoptera: Curculionoidea)*. vol.1. Melbourne, CSIRO Australia.