

PACIFIC COOPERATIVE STUDIES UNIT UNIVERSITY OF HAWAI'I AT MANOA

Department of Botany
3190 Maile Way
Honolulu, Hawai'i 96822
(808) 956-8218

Dr. David C. Duffy, Unit Leader

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BIOLOGICAL CONTROL OF *Miconia calvescens* BY PHYTOPHAGOUS ARTHROPODS

**Marcelo Coutinho Picanço¹, Robert Weingart Barreto², Elisangela
Gomes Fidelis³, Altair Arlindo Semeão³, Jander Fagundes Rosado³,
Shaiene Costa Moreno³, Emersom Cristi de Barros³, Gerson Adriano
Silva³ and Tracy Johnson⁴**

¹ Departamento de Biologia Animal, Universidade Federal de Viçosa, 36571-000 Viçosa, MG, Brazil. E-mail: picanco@ufv.br

² Departamento de Fitopatologia, Universidade Federal de Viçosa, 36571-000 Viçosa, MG, Brazil. E-mail: rbarreto@ufv.br

³ Agronomy students, Universidade Federal de Viçosa.

⁴ Institute of Pacific Islands Forestry, USDA Forest Service Pacific Southwest Research Station, P.O. Box 236, Volcano, Hawaii 96785

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1. ABSTRACT

More than 60 species of arthropods were found associated with *Miconia calvenscens* at two Brazilian sites in a one-year survey for potential biological control agents within the weed's native range in Minas Gerais, Brazil. Fifty-one insect species were collected, a majority of them phytophagous. Among the sap and cell feeders were two whitefly, a thrips species *Heliothrips* sp.n. (Thysanoptera: Thripidae), a psyllid *Diclidophlebia* sp. (Hemiptera: Psyllidae), an aphid species, and six species of leaf hoppers (five were species of Cicadellidae and one species of Flatidae). The psyllid and leaf hoppers appeared to warrant further evaluation, especially for their possible association with a lethal phytoplasm disease. Defoliators causing substantial damage included the leaf-roller *Ategumia* sp. (Lepidoptera: Pyralidae) and *Druentia* cf. *inscita* (Lepidoptera: Mimmallonidae), a sawfly *Atomacera petroa* (Hymenoptera: Argidae), and the leaf-cutter ant *Atta sexdens rubropilosa*. Stem-boring insects were discovered in low numbers and included an *Agrilus* sp. (Coleoptera: Buprestidae) that may be capable of killing stems. An *Apion* sp. (Coleoptera: Brentidae) was found associated with inflorescences. These collections include many species not discovered in earlier surveys of miconia in Brazil and Costa Rica, suggesting that additional potential arthropod agents await discovery in areas not yet explored.

2. INTRODUCTION

Miconia calvenscens DC. (Melastomataceae), a tree native to Central and South America, has become an aggressive invader of forest ecosystems in French Polynesia and Hawai'i following its introduction as an ornamental (Smith & Meyer 1998). *M. calvenscens* dominates over 65% of the island of Tahiti and has spread to nearby Moorea and Raiatea (Meyer 1996). The invasion is more recent and less advanced in Hawai'i, where efforts at containment and eradication have been underway on four islands for over a decade (Smith and Meyer 1998). However, in Hawai'i as well as Tahiti, the hope for ultimate management of this invader lies in classical biological control (Smith 2002). This method involves the importation and release of natural enemies from the plant's native region after a series of steps including: exploration for potential biocontrol agents, agent selection, rearing, host-range evaluation, life-cycle studies, and quarantining to eliminate hyperparasites (Julien 1997).

Previous surveys of arthropods associated with *M. calvenscens* were undertaken by the Hawai'i Department of Agriculture in 1993-94 in Costa Rica and in 1994 in Rio de Janeiro, Brazil (Burkhart 1995). These expeditions resulted in a list of over 50 species of insects belonging to the orders Lepidoptera, Coleoptera and Homoptera. Although numerous, these collections were made during very brief periods (several days for each locality). Such brief explorations are likely to miss potentially valuable biocontrol agents that may be uncommon or in life stages that are difficult to collect and identify, such as eggs or small larvae (Balciunas 2002). A more detailed study of this entomofauna was therefore regarded as necessary to complement the pioneering survey by Burkhart. Our purpose in the present study

was to discover additional phytophagous arthropods with potential for biocontrol of *M. calvescens* by surveying repeatedly for one year at two sites in the state of Minas Gerais, Brazil. Suitability of a few species was further evaluated in attempts at rearing under controlled conditions.

3. MATERIAL AND METHODS

3.1. Entomofauna of *Miconia calvescens*

Surveys of arthropods associated with *M. calvescens* were undertaken at two sites: Viçosa and Dionísio, both in Minas Gerais, Brazil. Viçosa is at an elevation of 649 meters and located at latitude 20°45'14"S and longitude 42°52'53"W. Average temperature is 19.4°C and average rainfall is 1221 mm/year. Dionísio is at an elevation of 344 meters and located at latitude 19°50'34"S and longitude 42°46'36"W. The local average temperature is 23.2°C and average rainfall is 1003 mm/year.

Surveys were conducted at intervals of approximately three weeks beginning in June 2001 and ending in July 2002, for a total of 14-15 visits to each site. Ten *M. calvescens* trees per site were chosen randomly for repeated sampling. Survey plants ranged 1-7 m in height and 6-150 mm in basal diameter at Viçosa and 1-4 m in height and 20-86 mm in basal diameter at Dionísio. Occurrence of all insects on selected miconia plants and neighboring plants was observed. Whenever an insect was observed both on *M. calvescens* and a neighboring plant the information was recorded. For each plant ten branches were randomly selected each visit and examined for arthropods. Numbers, position on the plant (stems, leaves, buds, flowers or fruits) and feeding habit were recorded for each arthropod species. This evaluation was made in the field, but whenever necessary parts of such plants were taken into the laboratory for further examination using a 100 x dissecting microscope. After evaluation individual specimens were collected, transported to the laboratory and deposited in a reference collection. Specimens were identified initially to order and, if possible, family. Those that were regarded as having potential for biocontrol were sent to taxonomists for identification.

4. RESULTS

More than 60 species of arthropods were found on *M. calvescens* including at least 51 insect species, three mite species and several spiders. Among the insect species 38 were phytophagous, three predaceous, six parasitoids, and four detritivorous. Among the phytophagous species, 18 were detected at a juvenile stage. Thirty-three phytophagous arthropods were associated with leaves, six were stem borers, and one was associated with fruits and flowers. Among the leaf-feeding arthropods species 18 were sap or cell feeders and 15 were defoliators.

4.1. Cell feeders

The cell feeding arthropods included three mite species and a thrips species. Their attack resulted in similar damage: a stippled yellowing pattern on leaves. Mite fauna was similar at the two sites. Mite populations were low overall and did not appear to have a significant impact on *M. calvescens* (Table 1).

Thrips was among the most damaging insects attacking *M. calvescens*. This insect was observed forming large groups composed of nymphs and adults feeding on the undersides of leaves. Colonized leaves turned yellow and became necrotic. Thrip populations were equivalent at the two localities. They occurred throughout the year at both sites. The largest populations of both nymphs and adults occurred during periods of lower temperature (Figures 1 and 2).

4.2. Sap feeders

Sap sucking insects observed attacking *M. calvescens* included two species of white flies, two scale insects, one aphid, six leaf hoppers and one psyllid (Table 1).

White flies were among the most damaging insects found on *M. calvescens*. The presence of nymphs and adults was associated with leaf discoloration. Two species occurred at both locations throughout the year. Adults of one species (sp.1) were around 1 mm long, about half the size of sp. 2. Sp. 1 was more abundant. The two white fly species had a denser population at Dionísio than at Viçosa (Table 1). The largest density of adults belonging to Sp. 1 occurred during lower rainfall and temperature periods and the largest density of Sp. 2 occurred at periods of lower temperature (Figures 1 and 3).

Two species of scale insects were found attacking leaves of *M. calvescens*. The density of the two species of scale insects was larger at Dionísio than at Viçosa (Table 1). Sp. 1 had a higher population density during periods of low rainfall and lower temperature. Sp. 1 was more abundant during periods of lower rainfall and lower temperature. Sp. 2 was more abundant during cooler periods. (Figures 1 and 4).

A species of wax-producing psyllid was found attacking shoots and young leaves. Population densities of nymphs and adults of the psyllid were larger at Dionísio than at Viçosa but they were present at the two sites throughout the year (Table 1, Figure 5). A coincidence of high populations of this psyllid with a rare but highly damaging phytoplasma-induced witches' broom disease observed on several plants at two sites (Seixas *et al.* 2002) suggests that this insect may be the vector of the only lethal disease so far observed in *M. calvescens* (Tomasi *et al.* 2000).

Six species of leafhoppers were found feeding on *M. calvescens*. Nymphs of two of these species were found on *M. calvescens*; for the other species only adults were found. Five of the leafhopper species belong to the Cicadellidae and one to the Flatidae. The most abundant Cicadellidae were *Empoasca* sp. and *Scaphytopius* sp. (Table 1). Leafhoppers of the family Cicadellidae are known to act as vectors for phytoplasma diseases (Casela *et al.* 1998), and therefore any of these species might vector the above-mentioned witches' broom. *Scaphytopius* sp. had a larger population density at Viçosa than at Dionísio. Nymphs and adults of *Scaphytopius* sp. were observed at both sites throughout the year. Largest nymph populations occurred during drier and cooler periods (Table 1, Figures 1 and 6). *Empoasca* sp. was more abundant at Dionísio than at Viçosa, particularly during April and June (Table 1, Figure 7).

One aphid species was found attacking *M. calvescens* during May and June of 2002 at Dionísio. Three stinkbug species (Pentatomidadae) were found but always in low numbers (Table 1, Figure 8).

4.3. Defoliators

Defoliating insects observed on *M. calvescens* included eight lepidopteran species, one sawfly (*Atomacera petroa* Smith), leaf cutter ants (*Atta sexdens rubropilosa*) and adults of some beetle species. Coleoptera adults occurred were uncommonly found on *M. calvescens* leaves. Adults of two species of Buprestidae and two Curculionidae found feeding on *M. calvescens* leaves, are known to have larvae that are stem-borers (Table 2).

The most damaging of all lepidopteran species was a leaf roller, *Ategumia* sp. (Pyralidae). This species rolled leaves longitudinally, forming cylinders where the larvae hid and eventually pupated. Adults were greyish-brown moths 1 - 1,5 cm long with yellow spots on their wings. Their eggs were green and laid in groups covered with a thin transparent sheet. Miconia plants were defoliated up to 50% following attack by this species. Potted plants of the Hawaiian biotype that were left at one field site also were attacked by this species. *Ategumia* sp. caterpillars were observed at the two sites throughout the year. *Ategumia* sp. was more damaging at Dionísio, where populations were peaked in January 2002. At Viçosa this species was found only at low densities. The largest densities of *Ategumia* sp. caterpillars occurred during periods of higher temperature (Table 2, Figures 1 and 9).

Druentia cf. *inscita* (Mimallonidae) caterpillars were observed attacking *M. calvescens*. These caterpillars were green with brown stripes and were approximately 5 cm long at their final stage of development. They fed mostly on apical foliage, destroying the lamina of young leaves. On older leaves this species also was a leaf roller. This species was also more abundant at Dionísio than at Viçosa. The highest damage to plants was observed from March to May of 2002. This caterpillar was more abundant during warmer periods of the year. Caterpillars collected in the field pupated in the laboratory and metamorphosed into adults, but no egg laying has been observed (Table 2, Figures 1 and 10).

Antiblemma sp. (Noctuidae) caterpillars were also observed defoliating *M. calvescens*. These caterpillars move like a typical Geometridae, they are green at the beginning of the larval stage and become violet at later stages of larval development. Initially they bore small holes on the leaves but as they grow the size of these holes grow in size leading to significant loss of lamina areas. These caterpillars were found at the two locations throughout the year with no significant peaks in population density (Table 2, Figure 11).

Caterpillars of a Limacodidae species were observed attacking *M. calvescens* on two occasions (June 2001 and June 2002) at Dionísio. These insects were found in low densities on both occasions but were nevertheless capable of causing some defoliation of plants (Table 2, Figure 12).

One sawfly species *A. petroa* (Hymenoptera: Argidae) had larvae attacking *M. calvescens* leaves and producing distinctive linear scars on the upper lamina. Heavy

damage appeared to lead to leaf drop. When common, 6 sawfly larvae up to 1 cm long could be found on the upper side of a single leaf. *A. petroa* larvae were observed at both sites throughout the year. *A. petroa* was more abundant at Dionísio, where populations peaked in November-December 2001 and April 2002. Populations at both sites peaked in a period of high air temperature. Attempts to rear this species were unsuccessful. The larvae survived for up to five days after transfer to the laboratory or the greenhouse (Table 2, Figures 1 and 13).

Intense defoliating activity by leaf cutting ants (*A. sexdens rubropilosa*) was observed at Dionísio. The ants were also seen harvesting fruits of *M. calvescens*. The attack of this ant species was observed throughout the year at both sites (Table 2, Figure 14). Unfortunately, despite the significant damage to miconia this species has no potential as a biocontrol agent of *M. calvescens* since it is well known as a major generalist crop pest attacking most dicotyledons cultivated in Brazil (Della Lucia, 1993, Anjos *et al.* 1998).

4.4. Stem borers

Adults of several species of stem boring Coleoptera were collected, but larvae of only one *Agrilus* sp. (Buprestidae) were confirmed as capable of boring stems of *M. calvescens*. *Agrilus* sp. larvae, judging from evidence of their feeding galleries, appeared to be capable of killing branches and even whole plants. However our observations did not allow us to establish a definite causal link between this insect and plant mortality: it is possible that it attacked tissue that was already dead or dying. Attack by the larvae started at the external part of the stems and from there they dig tunnels towards the central part of the stems. This group of insects normally lays its eggs on thinner and tender branches. Pupae were found inside the galleries. Larvae, adults and stem damage were observed at the two sites. Larvae were observed at Viçosa from November 2001 to February 2002 and in May 2002 at Dionísio. Adults were seen from June to December of 2001 in Viçosa. In Dionísio adults were seen in August 2001, January, February and June 2002 in Dionísio. Stem boring was noticed from June 2001 to January 2002 in Viçosa and in November 2001 and January 2002 in Dionísio (Table 2, Figure 15).

Two individual adults of another Buprestidae species collected at Itabira, MG were maintained for two months feeding on Brazilian and Hawaiian biotypes of miconia. This species appears to have biocontrol potential. A new visit to the area of Itabira where this insect was collected was made in June 2003 but no insects of this species were found. Another attempt will be made during a warmer period (Figure 16).

Naupactus spp. (Coleoptera: Curculionidae) was commonly encountered in low numbers. Insects of this species were most abundant at Dionísio during months with lower air temperature (Table 2, Figures 1 and 17).

4.4. Flower and fruit feeders

Apion sp. (Coleoptera: Brentidae) adults were observed on leaves of *M. calvescens* throughout the year, but at low densities. Their higher densities occurred during periods of higher temperature (Table 2, Figures 1 and 18). Adults were 2 - 3 mm long and were black with thin yellow legs. Larvae of this genus are known to feed

on fruits, seeds and inflorescences (Norambuena & Piper, 2000) as well as superficially boring stems (Knodel & Charlet, 2002), nevertheless larvae of this beetle were not observed on flowers, fruits of stems.

4.5. Other arthropods

Eriophyid mite induced galls on *M. calvescens* plants similar to the Hawaiian biotype (Fig 18) were observed during a survey for miconia pathogens in Ecuador in May 2000 (R.W.B. unpublished data), and apparently also were observed by Burkhart (1995) near Rio de Janeiro in 1994. Throughout the investigations by R.W.B. in Brazil, similar galls were widely found on other species of *Miconia*, often causing severe damage to leaves, flowers and fruits (e.g.: *Miconia prasina* [Sw.] DC.), but never on *M. calvescens*. Galls that appeared to be caused by eriophyids were also found on *M. calvescens* recently by entomologists in Costa Rica (Paul Hanson, personal communication). Eriophyid mites are often regarded by entomologists as having poor biocontrol potential since they can be heavily predated by other mites, however in some cases they do appear capable of providing effective control (Piper & Andres 1995).

5. CONCLUSIONS AND RECOMMENDATIONS

Over 60 species of arthropods were found associated with *Miconia calvescens* during our systematic survey at two sites in the state of Minas Gerais, Brazil. The great majority of species observed during this study were different from those recorded by Burkhart (1995). Only the lepidopterous *Antegumia* sp. (Pyralidae), *Antiblemma* sp. (Noctuidae) and *Druentia* cf. *inscita* (Mimallonidae) were recorded in both studies. This indicates that a diverse entomofauna exists in association with this species, offering a range of potential candidates for use in classical biocontrol.

Observations in the field suggest that the following species are sufficiently damaging to *M. calvescens* to warrant further evaluation as potential biocontrol agents: a whitefly species 1, *Diclidophlebia* sp. (Hemiptera: Psyllidae), *Heliothrips* sp.n (Thysanoptera: Thripidae), *Ategumia* sp. (Lepidoptera: Pyralidae), *Druentia* cf. *inscita* (Lepidoptera: Mimallonidae), *Atomacera* sp. (Hymenoptera: Argidae), *Agrilus* sp. (Coleoptera: Buprestidae) and another unidentified buprestid. Additional efforts to rear and document the life cycle of these insects are needed.

Specimens of selected species were sent to taxonomists for identification but for some groups no experts are available in Brazil. Several of the insects that were collected, clearly represent new species that will require description, naming and publication. Support from taxonomic specialists will be critical.

An effort to elucidate the link of potential vectors for witches broom disease and molecular characterization of the pathogen involved (probably a phytoplasma) are recommended. This disease was observed to be highly lethal, even to adult miconia.

Expansion of the arthropod survey to new areas of occurrence of this plant in Brazil is recommended. This will probably yield a larger range of pathogens and herbivores that may be useful in miconia biocontrol. A comparison of the arthropod fauna between Brazil and Costa Rica, where a similar survey is being undertaken on

a different miconia biotype, will then become feasible and will help build a more complete image of the target plant and its natural enemies.

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6. LITERATURE

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Table 1. Individuals collected of sap feeding insects on *Miconia calvescens* at Viçosa and Dionísio in Minas Gerais State, Brazil. 2001/02.

Taxon	Observed stage*	Total of collected individuals											
		Total		Leaves		Stem		Buds		Flowers		Fruits	
		Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio
Acari sp.1	A	16	84	16	84	0	0	0	0	0	0	0	0
Acari sp.2	A	55	55	54	53	1	1	0	1	0	0	0	0
Acari sp.3	A	15	11	13	10	1	0	1	0	0	1	0	0
Thysanoptera: Thripidae: Panchaetothripinae	N, A												
<i>Heliothrips</i> sp.n	N	948	943	948	943	0	0	0	0	0	0	0	0
<i>Heliothrips</i> sp.n	A	880	631	880	631	0	0	0	0	0	0	0	0
Hemiptera: Aleyrodidae 1													
Nymphs		543	1469	543	1469	0	0	0	0	0	0	0	0
Adults		233	178	233	178	0	0	0	0	0	0	0	0
Hemiptera: Aleyrodidae 2	N, A												
Nymphs		212	307	212	307	0	0	0	0	0	0	0	0
Adults		43	22	43	22	0	0	0	0	0	0	0	0
Hemiptera: Diaspididae 1	N, A	67	108	67	108	0	0	0	0	0	0	0	0
Hemiptera: Diaspididae 2	N, A	127	681	111	673	0	1	7	5	9	2	0	0
<i>Diclidophlebia</i> sp. (Hemiptera: Psyllidae)	O, N, A												
Nymphs		769	59	0	0	0	0	769	59	0	0	0	0
Adults		93	945	0	0	0	0	93	945	0	0	0	0
Hemiptera: Aphididae	N, A	0	30	0	30	0	0	0	0	0	0	0	0
Hemiptera: Flatidae	N, A	32	10	11	5	0	0	16	4	0	0	5	1
Nymphs		32	10	11	5	0	0	16	4	0	0	5	1
<i>Empoasca</i> sp. (Hemiptera: Cicadellidae)	N, A												
Nymphs		9	161	9	145	0	0	0	8	0	1	0	7
Adults		28	244	26	221	0	8	0	9	2	5	0	1
<i>Scaphytopius</i> sp. (Hemiptera: Cicadellidae)	N, A												
Nymphs		10	13	7	12	0	0	3	1	0	0	0	0
Adults		59	6	50	3	4	0	5	3	0	0	0	0
Hemiptera: Cicadellidae 1	A	10	13	7	12	0	0	3	1	0	0	0	0
Hemiptera: Cicadellidae 2	A	12	2	11	1	0	0	0	1	0	0	1	0
Hemiptera: Cicadellidae 3	A	2	9	2	8	0	0	0	0	0	1	0	0
Hemiptera: Miridae	A	16	34	12	29	3	3	0	1	0	1	1	0
Hemiptera: Pentatomidae 1	A	13	2	13	2	0	0	0	0	0	0	0	0
Hemiptera: Pentatomidae 2	A	13	0	12	0	0	0	0	0	1	0	0	0
Hemiptera: Pentatomidae 3	A	0	14	0	14	0	0	0	0	0	0	0	0

N = nymphs and A = adults.

Table 2. Individuals collected of stem boring, foliage feeding and flower and fruit feeding insects on *Miconia calvescens* at Viçosa and Dionísio in Minas Gerais State, Brazil. 2001/02.

Taxon	Observed stage*	Total of collected individuals											
		Total		Leaves		Stem		Buds		Flowers		Fruits	
		Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio
FOLIAGE FEEDERS													
<i>Diabrotica speciosa</i> (Coleoptera: Chrysomelidae: Galerucinae)	A	3	0	2	0	0	0	0	0	0	0	1	0
<i>Cerotoma</i> sp. (Coleoptera: Chrysomelidae: Galerucinae)	A	2	1	2	1	0	0	0	0	0	0	0	0
Coleoptera: Chrysomelidae: Alticinae	A	24	26	22	26	1	0	1	0	0	0	0	0
Coleoptera: Chrysomelidae: Cassidinae	A	0	4	0	4	0	0	0	0	0	0	0	0
Coleoptera: Chrysomelidae: Eumolpinae	A	0	5	0	4	0	0	0	1	0	0	0	0
<i>Antegumia</i> sp. (Lepidoptera: Pyralidae)	L	14	84	14	84	0	0	0	0	0	0	0	0
<i>Antiblemma</i> sp. (Lepidoptera: Noctuidae)	L	4	18	4	17	0	1	0	0	0	0	0	0
<i>Druentia</i> cf. <i>inscisa</i> (Sch.) (Lepidoptera: Mimallonidae)	L	13	96	11	96	0	0	0	0	2	0	0	0
Limacodidae	L	20	10	16	8	0	2	4	0	0	0	0	0
Lepidoptera 1	L	11	5	10	5	0	0	0	0	1	0	0	0
Lepidoptera 2	L	2	2	2	2	0	0	0	0	0	0	0	0
Lepidoptera 3	L	9	2	9	2	0	0	0	0	0	0	0	0
Lepidoptera 4	L	2	73	2	71	0	1	0	1	0	0	0	0
<i>Atomacera petroa</i> Smith (Hymenoptera: Argidae) Larvae	L, A	31	59	29	59	0	0	0	0	0	0	0	0
<i>Atta sexdens rubropilosa</i> (Hymenoptera: Formicidae)	A	546	317	278	262	243	27	13	26	5	1	7	1
STEM BORERS													
<i>Agrilus</i> sp. Curtis, 1825 (Coleoptera: Buprestidae) Adults	L, A	18	16	14	15	3	0	1	1	0	0	0	0
Larvae		2	15	0	0	2	15	0	0	0	0	0	0
Exit holes		46	12	0	0	46	12	0	0	0	0	0	0
<i>Eburodacrys monticola</i> Monné & Martins, 1973 (Coleoptera: Cerambycidae)	A	1	0	0	0	0	0	0	0	0	0	0	0
<i>Naupactus</i> spp. Schönherr, 1833 (Coleoptera: Curculionidae)	A	0	55	0	47	0	4	0	4	0	0	0	0
Coleoptera: Curculionidae: Cryptorhynchini	A	0	1	0	1	0	0	0	0	0	0	0	0
FRUITS AND FLOWERS													
<i>Apion</i> sp. Herbst, 1797 (Coleoptera: Brentidae)	A	9	48	9	48	0	0	0	0	0	0	0	0

L = larvae and A = adults.

Table 3. Individuals collected of predatory or parasitoid arthropods observed on the foliage of *Miconia calvescens* at Viçosa and Dionísio in Minas Gerais State, Brazil. 2001/02.

Taxon	Observed stage*	Total of collected individuals											
		Total		Leaves		Stem		Buds		Flowers		Fruits	
		Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio
PREDATORS													
Arachnida													
Aranae (several species)	A	404	546	375	500	10	21	15	15	0	8	4	2
Insecta													
Neuroptera: Chrysopidae													
<i>Chrysoperla</i> sp.	E, L, A												
Eggs		220	32	220	32	0	0	0	0	0	0	0	0
Adults		4	8	1	8	0	0	2	0	0	0	1	0
Coleoptera: Histeridae	A	29	19	29	19	0	0	0	0	0	0	0	0
Coleoptera: Coccinellidae	A	1	3	1	3	0	0	0	0	0	0	0	0
PARASITOIDS													
<i>Encarsia</i> sp. (Hymenoptera: Aphelinidae)	A	1	0	1	0	0	0	0	0	0	0	0	0
<i>Opius</i> sp. (Hymenoptera: Aphelinidae)	A	4	34	4	33	0	0	0	1	0	0	0	0
Hymenoptera: Aphelinidae 1	A	131	20	78	20	9	0	20	0	0	0	24	0
Hymenoptera: Braconidae 1	A	11	70	11	20	0	0	0	18	0	6	0	26
Hymenoptera: Braconidae 2	A	34	16	34	14	0	0	0	1	0	0	0	1
<i>Trichogramma</i> sp. (Trichogrammatidae)	A	4	15	4	14	0	0	0	0	0	1	0	0

* E = Eggs, L = larvae, and A = adults.

Table 4. Individuals collected of detritivorous insects observed on the foliage of *Miconia calvescens* at Viçosa and Dionísio in Minas Gerais State, Brazil. 2001/02.

Taxon	Observed stage*	Total of collected individuals											
		Total		Leaves		Stem		Buds		Flowers		Fruits	
		Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio	Viçosa	Dionísio
Blattodea	A	18	38	16	26	0	3	2	5	0	4	0	0
Collembola	Y, A	13	5	13	2	0	0	0	3	0	0	0	0
Diptera 1	A	0	13	0	13	0	0	0	0	0	0	0	0
Diptera 2	A	0	2	0	1	0	0	0	0	0	0	0	1

Y = Young and A = adults.

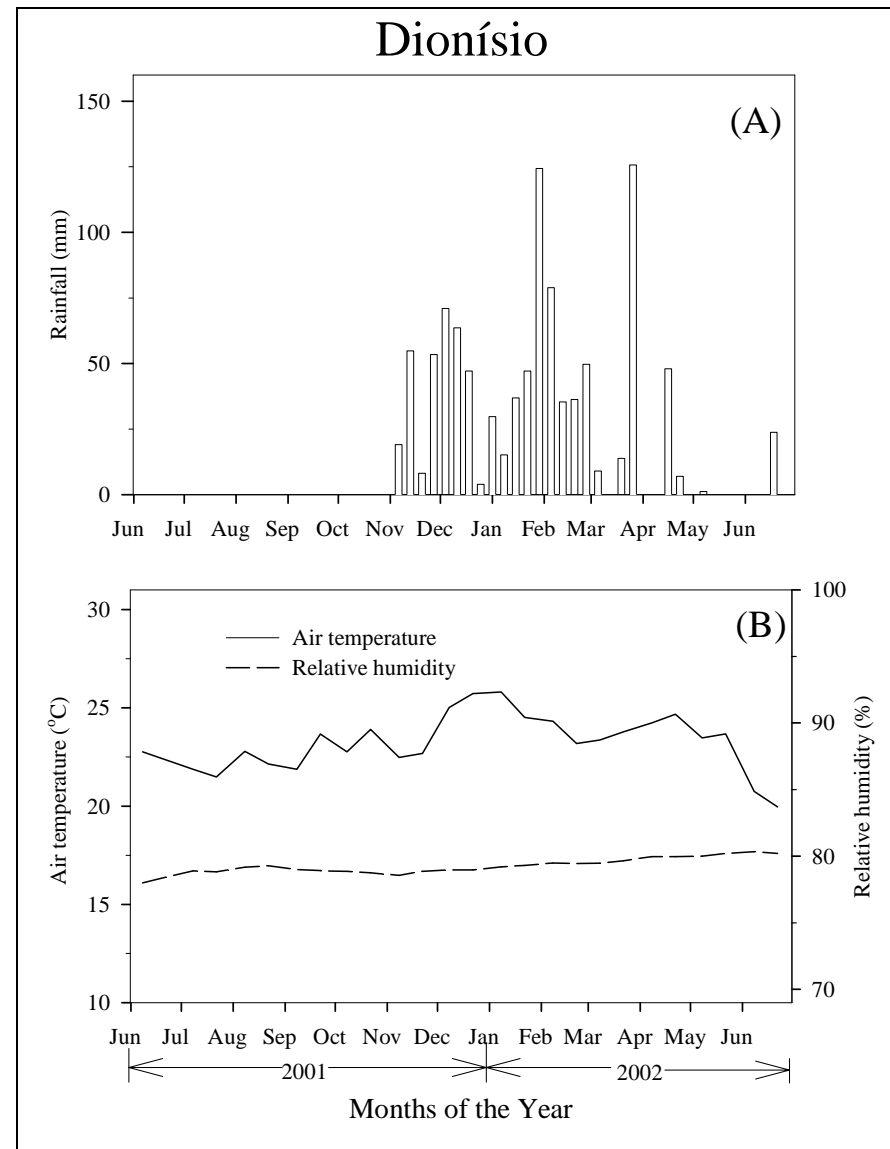
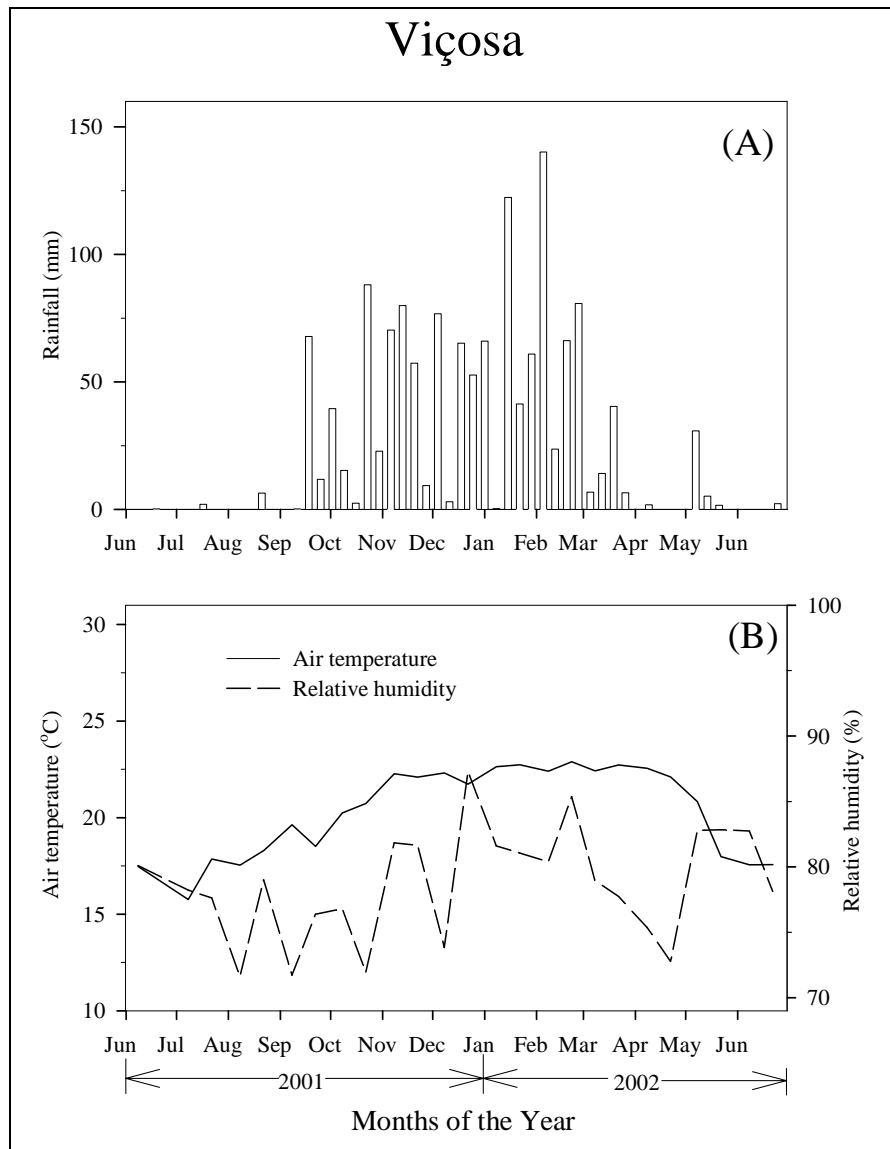


Fig 1. Rainfall, air temperature, and relative humidity at Viçosa and Dionísio, Minas Gerais State, Brazil. 2001/02.

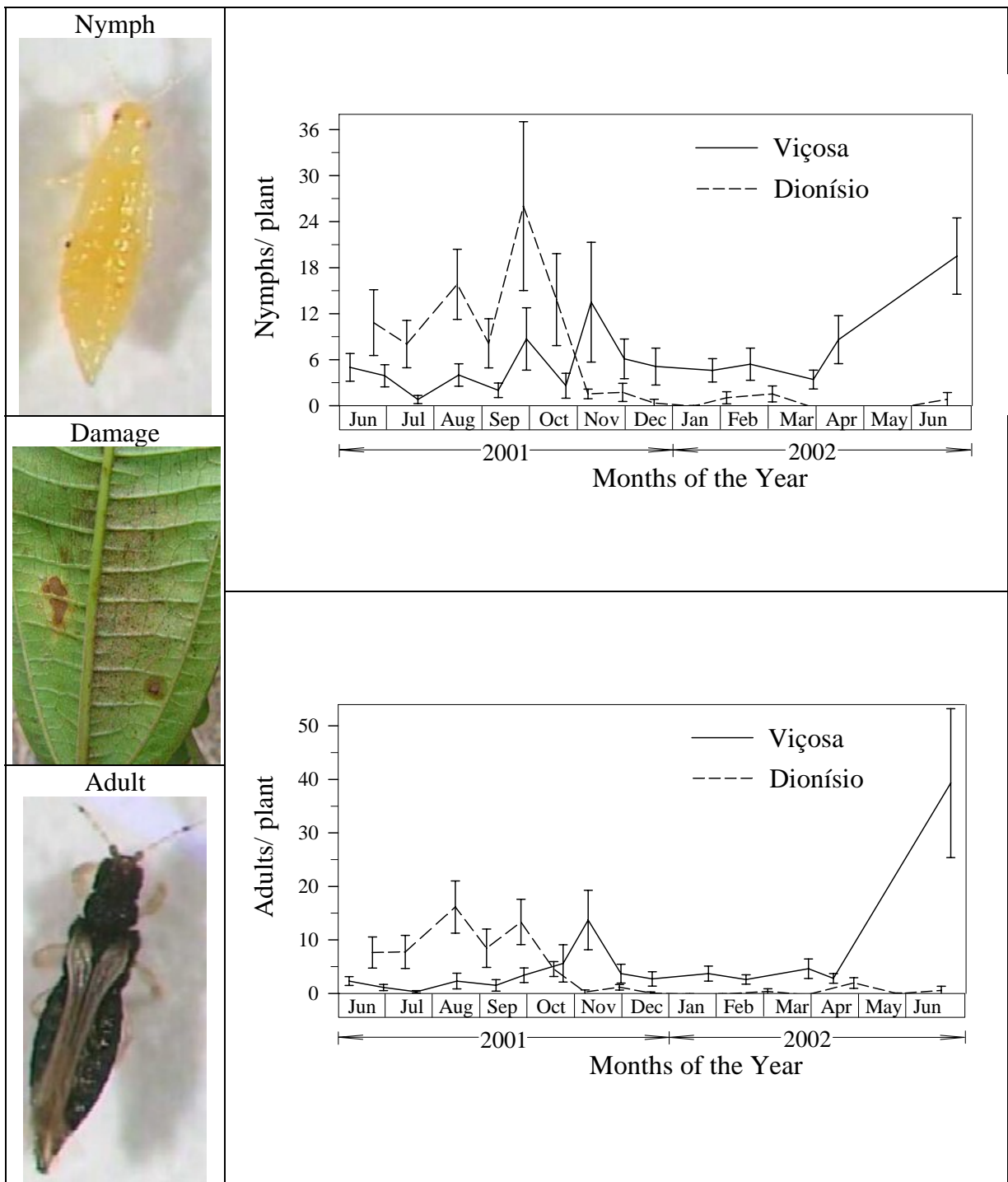


Fig 2. Population density of (A) nymphs and (B) adults of *Heliothrips* sp.n. (Thysanoptera: Thripidae: Panchaethripinae) on *Miconia calvescens* leaves at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

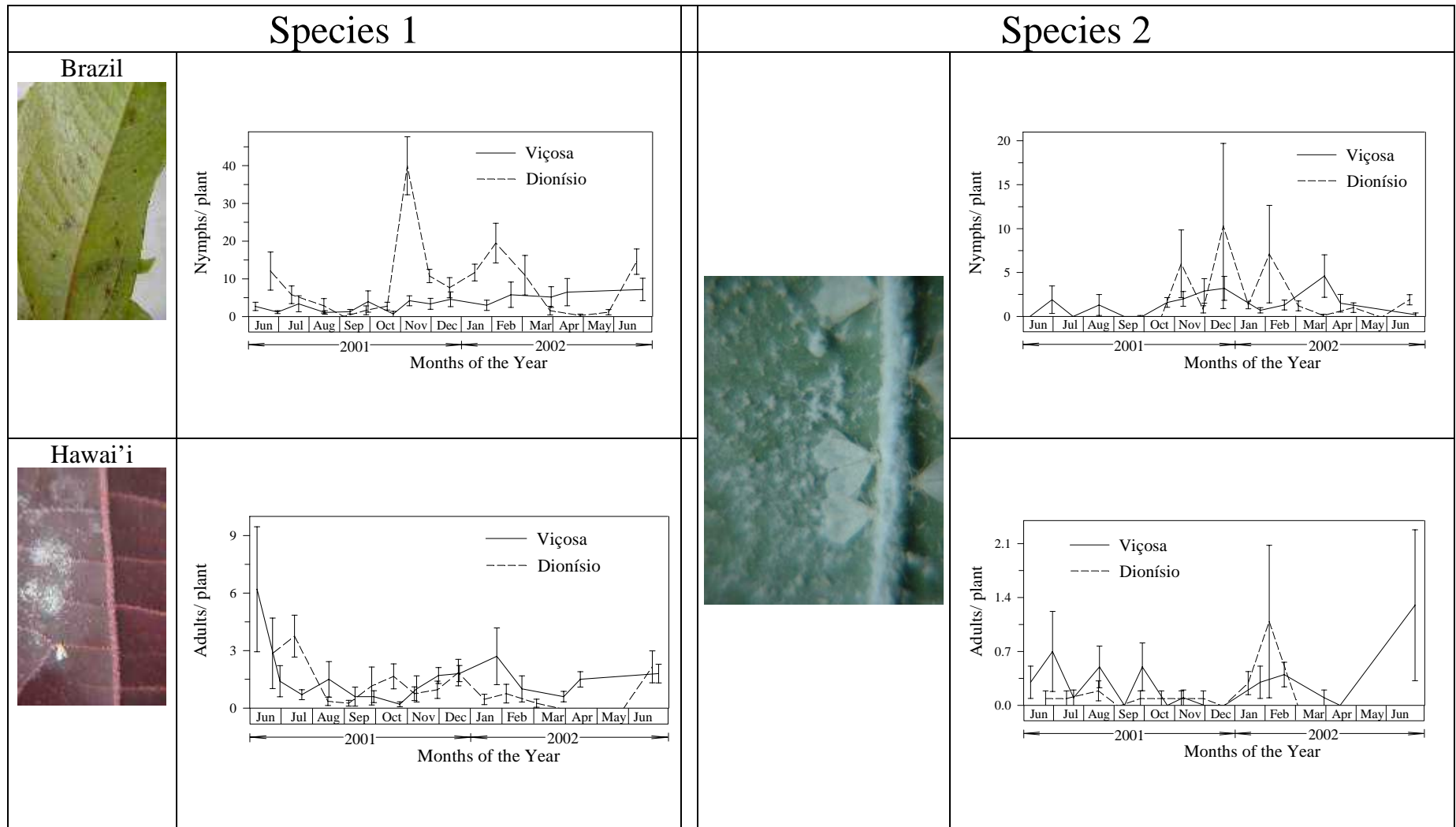


Fig. 3. *Miconia calvescens* leaves (Brazilian and Hawaiian biotype) attacked by two species of white flies (Hemiptera: Aleyrodidae) and population fluctuation for those two species at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/2. Bars = Standard error for the means.

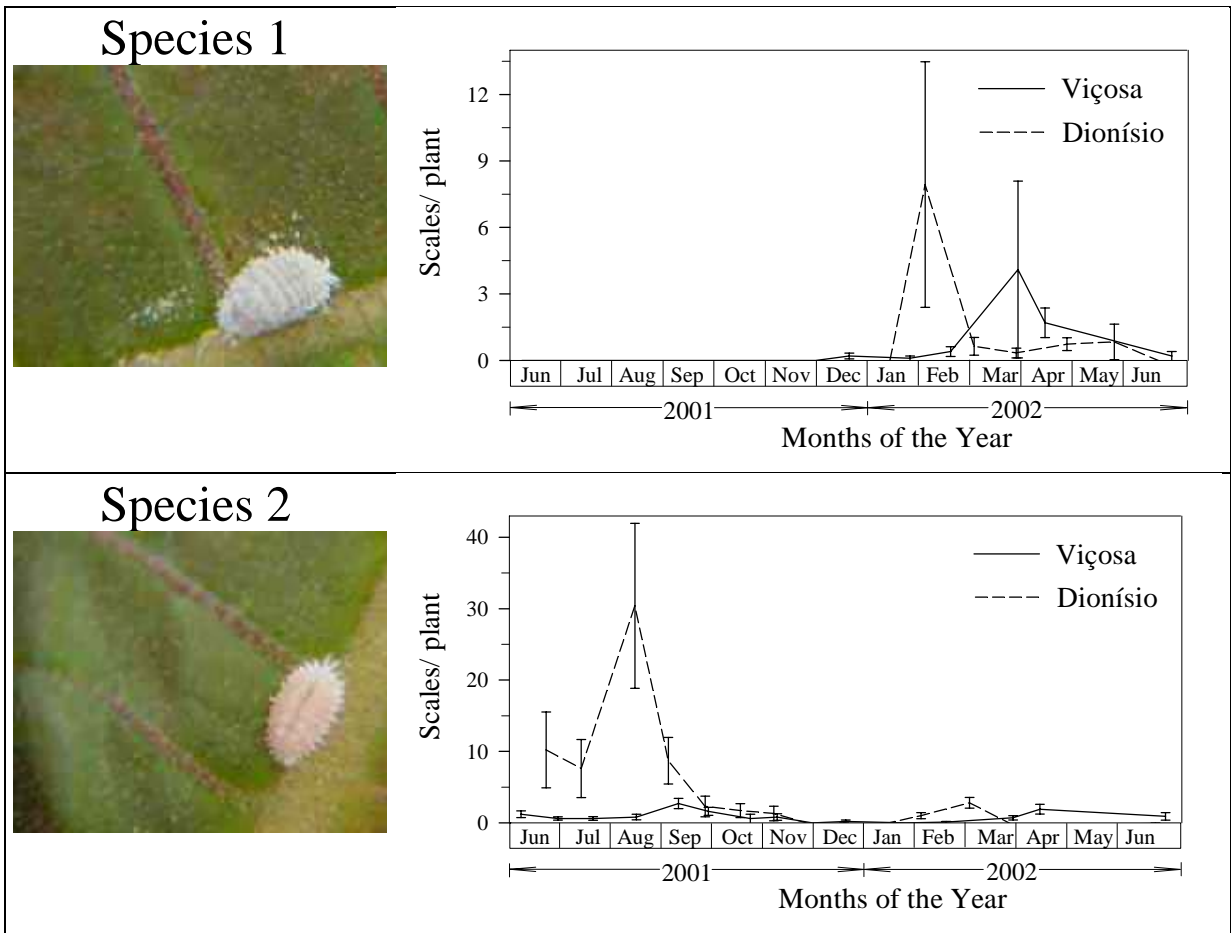
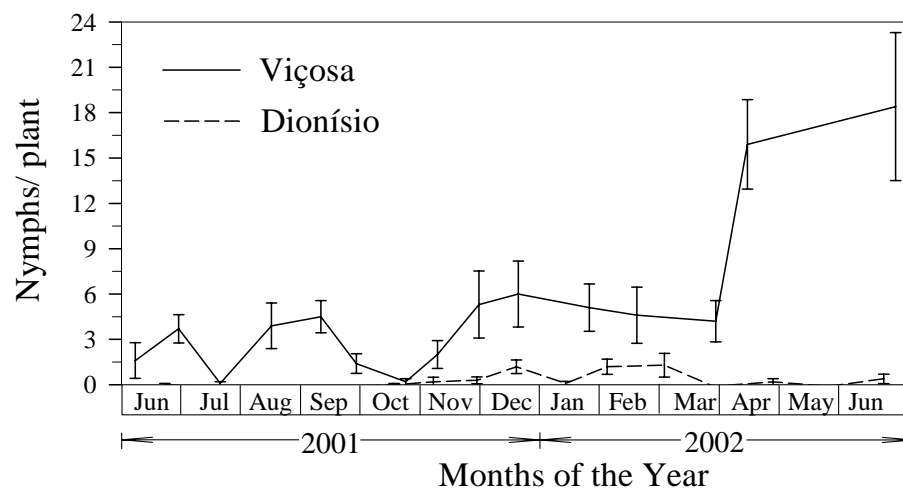


Fig. 4. Population density of scale insects (Hemiptera: Diaspididae) on *Miconia calvescens* leaves in Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

Nymphs



Adults

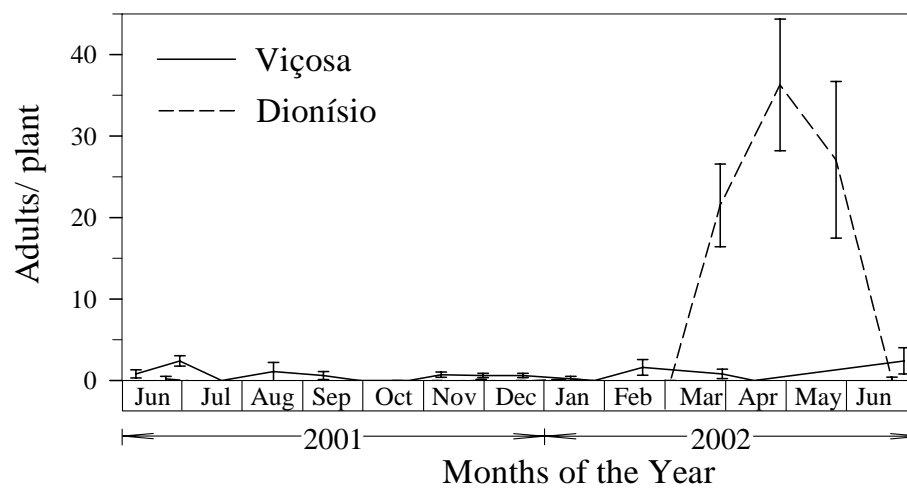


Fig. 5. Population density of nymphs and adults of *Diclidophlebia* sp. (Hemiptera: Psyllidae) on *Miconia calvenscens* in Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

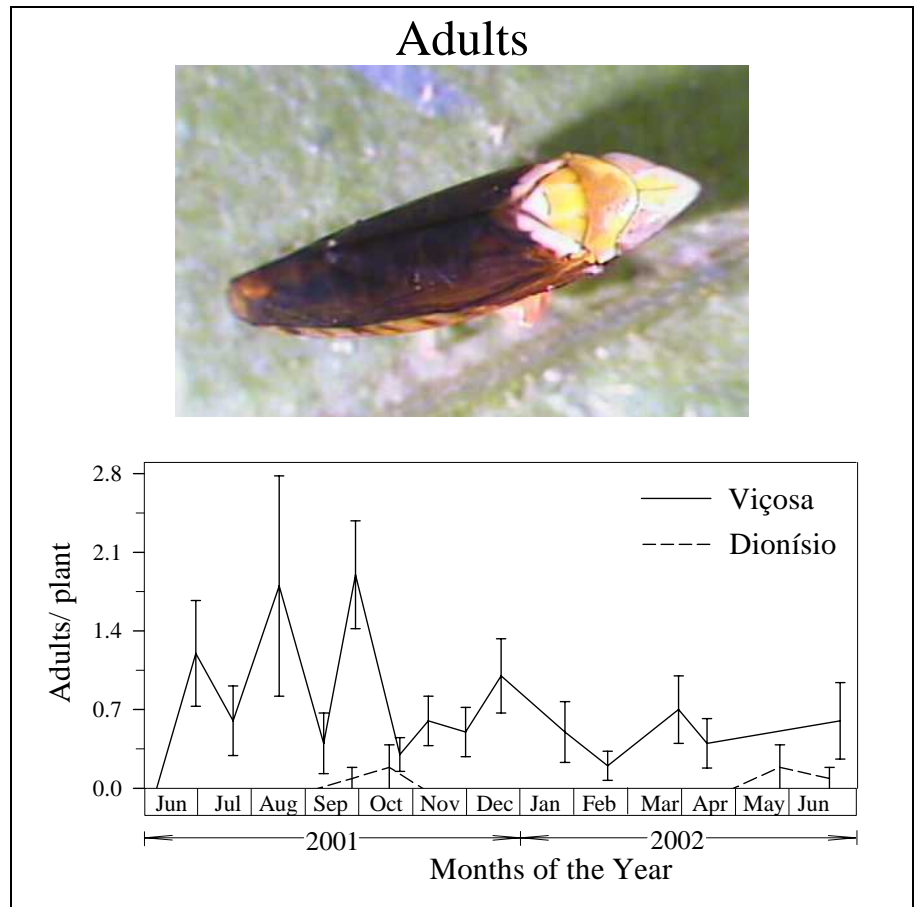
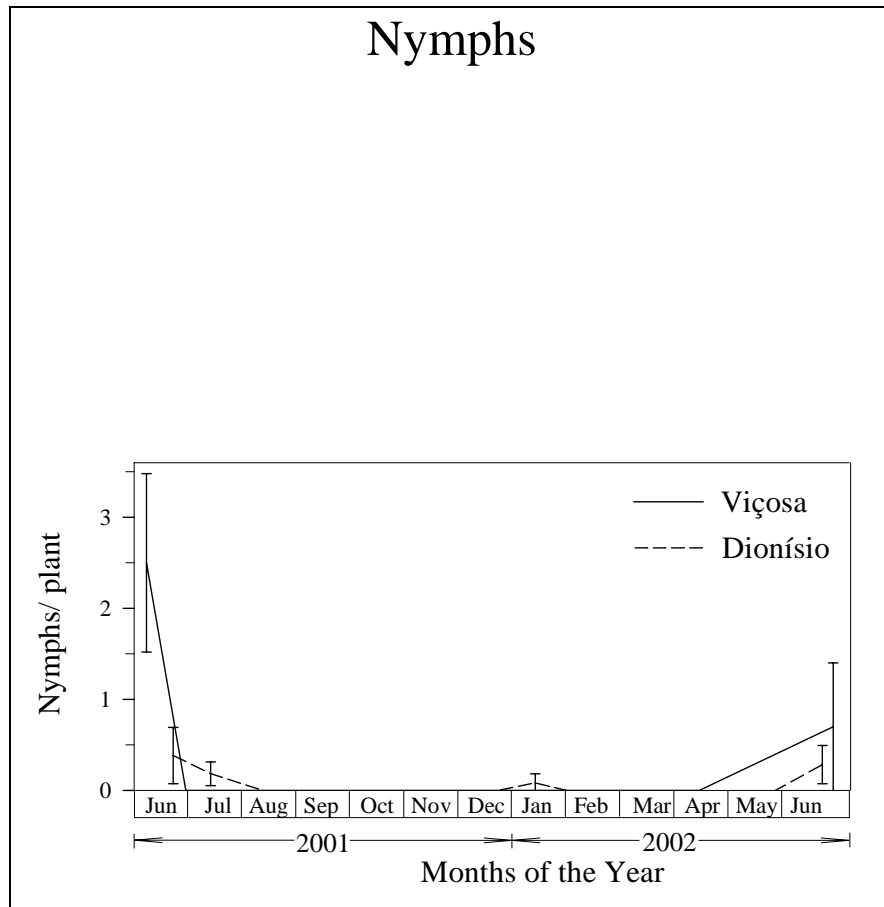
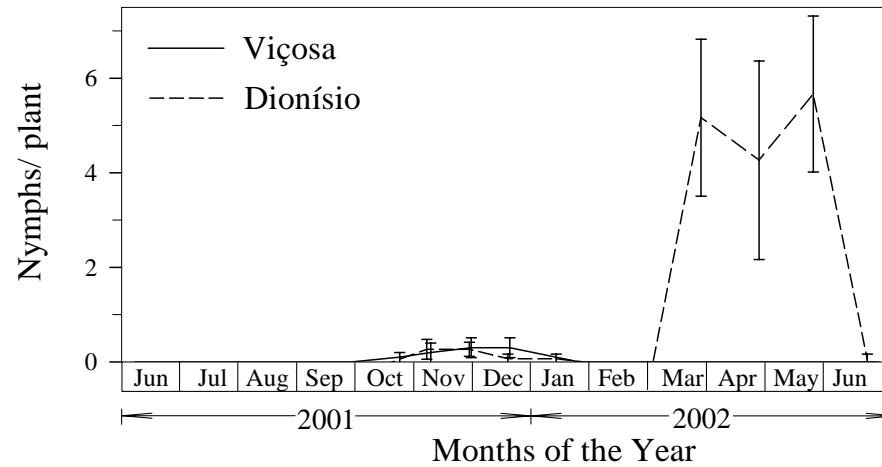


Fig. 6. Population density of nymphs and adults of *Scaphytopius* sp. Ball (Hemiptera: Cicadellidae) on *Miconia calvescens* in Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means

Nymph



Adult

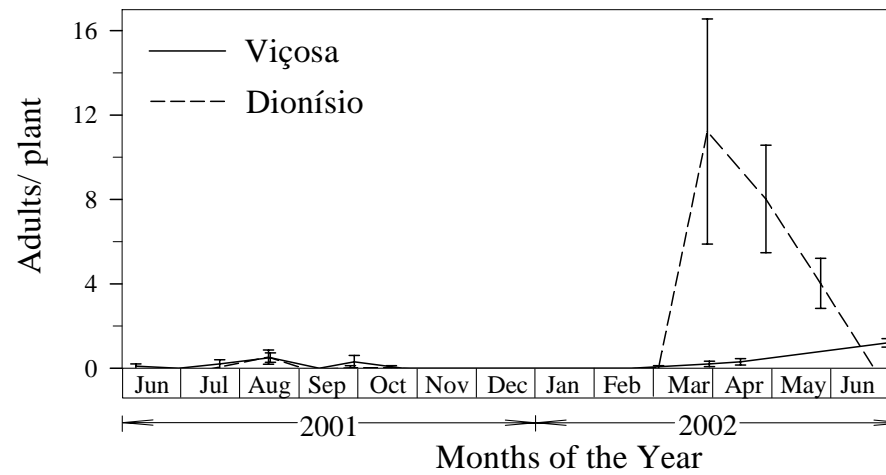


Fig. 7. Population density of (A) nymphs and (B) adults of *Emposaca* sp. nymphs (Hemiptera: Cicadellidae) on *Miconia calvescens* in Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

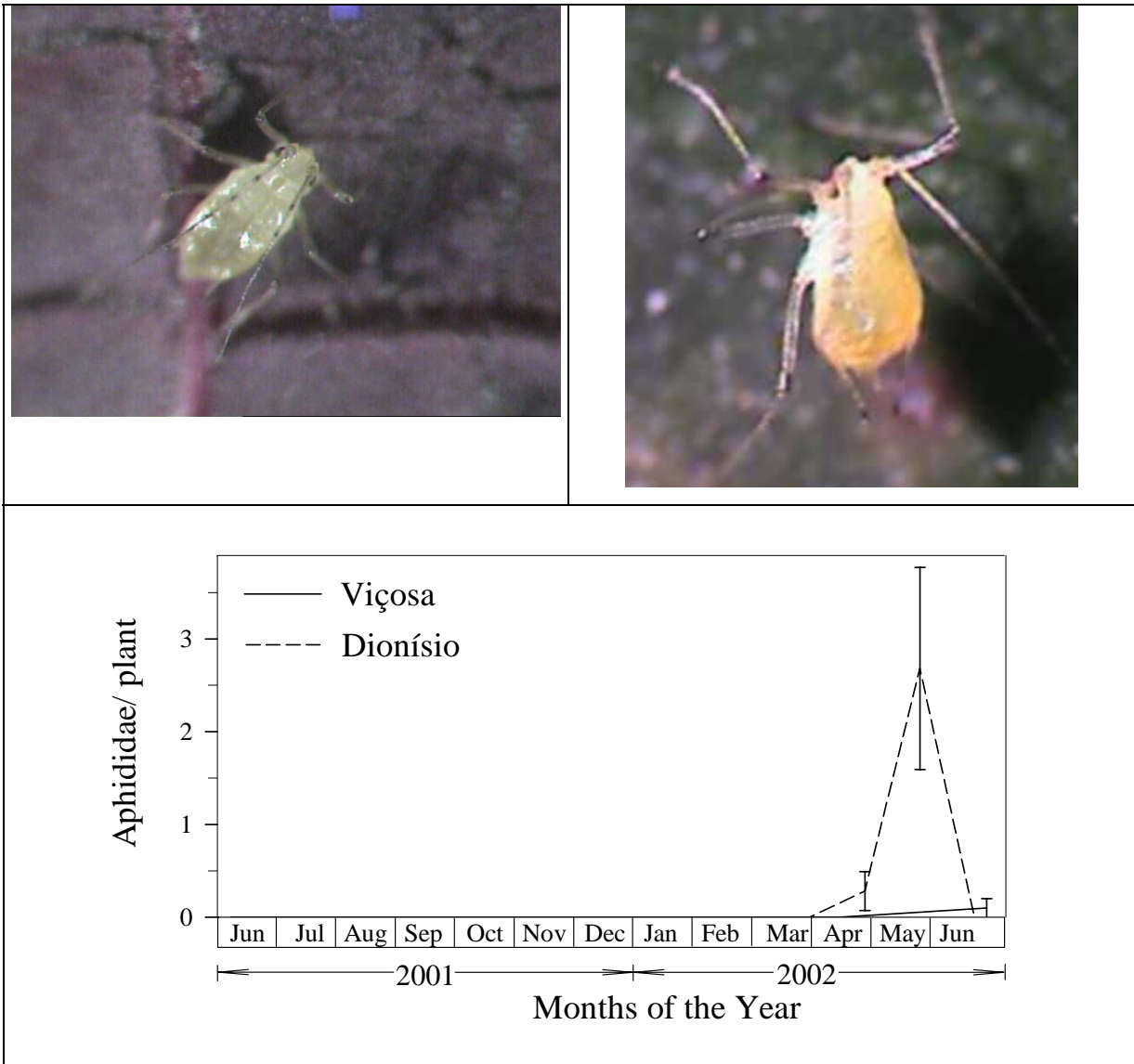


Fig 8. Attack intensity of aphids (Hemiptera: Aphididae) on leaves of *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

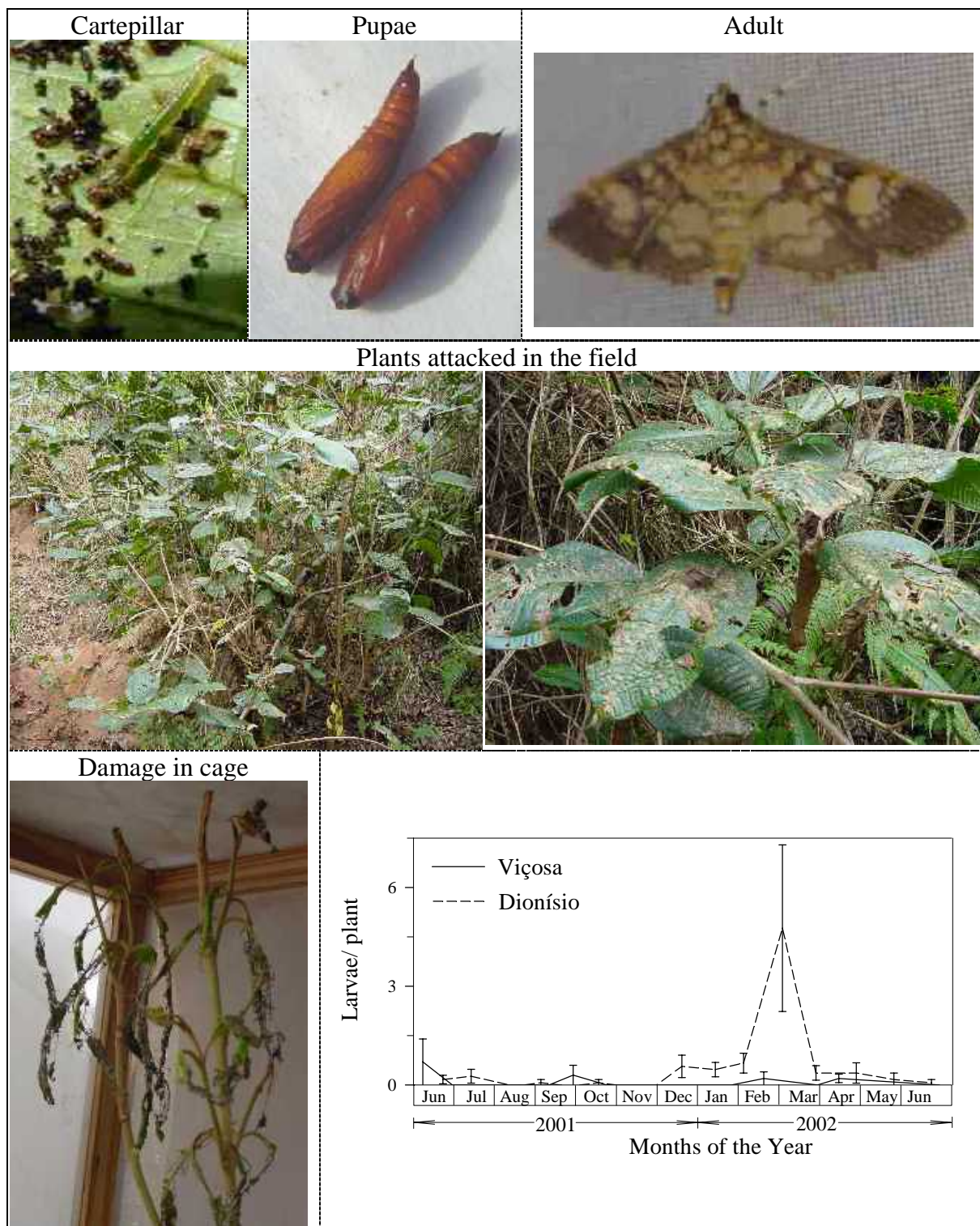


Fig. 9. Population density of *Antegumia* sp. (Lepidoptera: Pyralidae) on leaves of *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

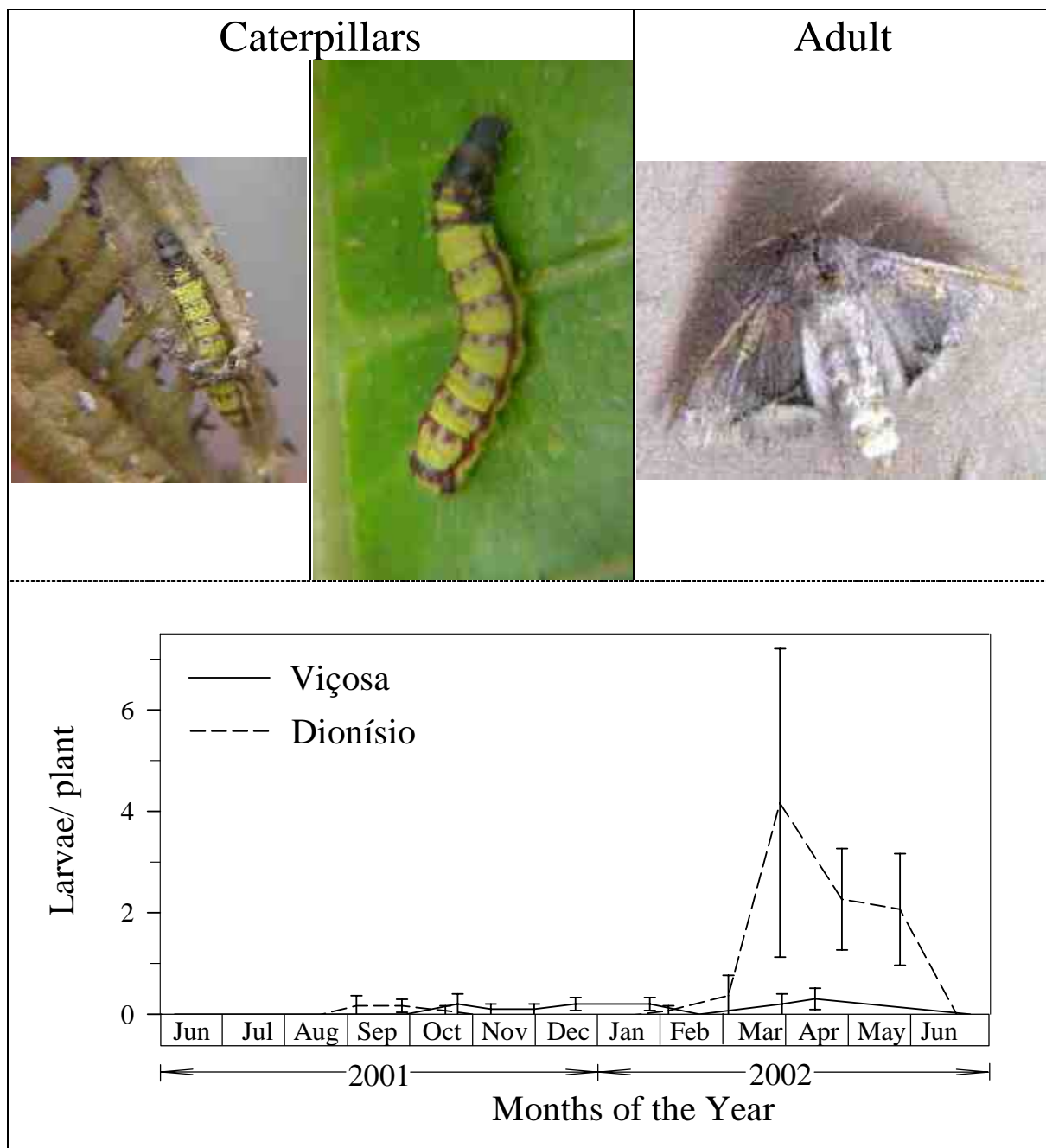


Fig. 10. Population density of *Druentia cf. inscita* (Schaus) (Lepidoptera: Mimallonidae) on *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil, 2001/02. Bars = Standard error for the means.

Caterpillar

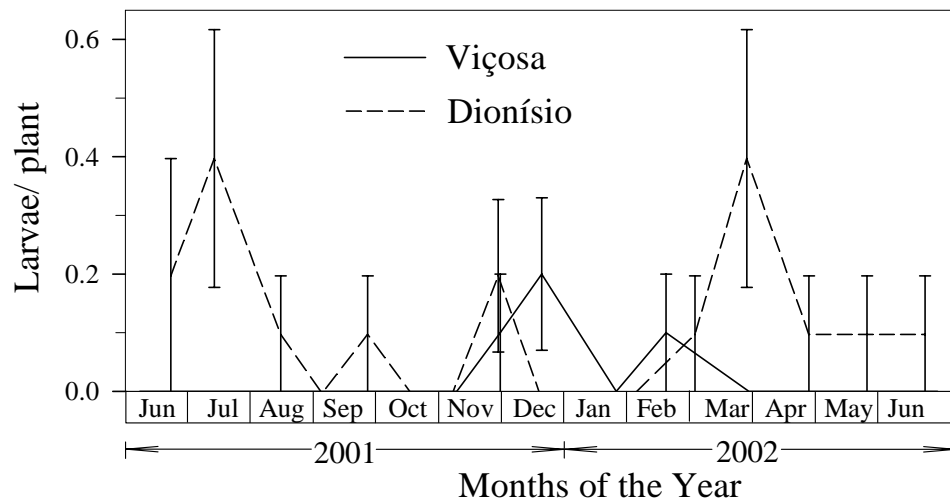


Fig. 11. Population density of *Antiblemma* sp. (Lepidoptera: Noctuidae) on *Miconia calvenscens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

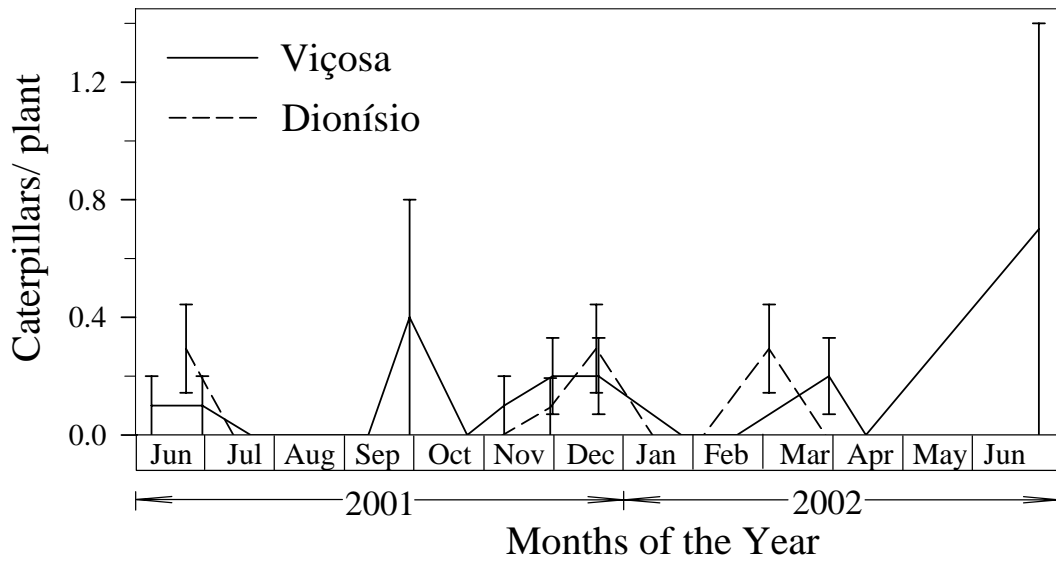


Fig. 12. Population density of Lepidoptera: Limacodidae on *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

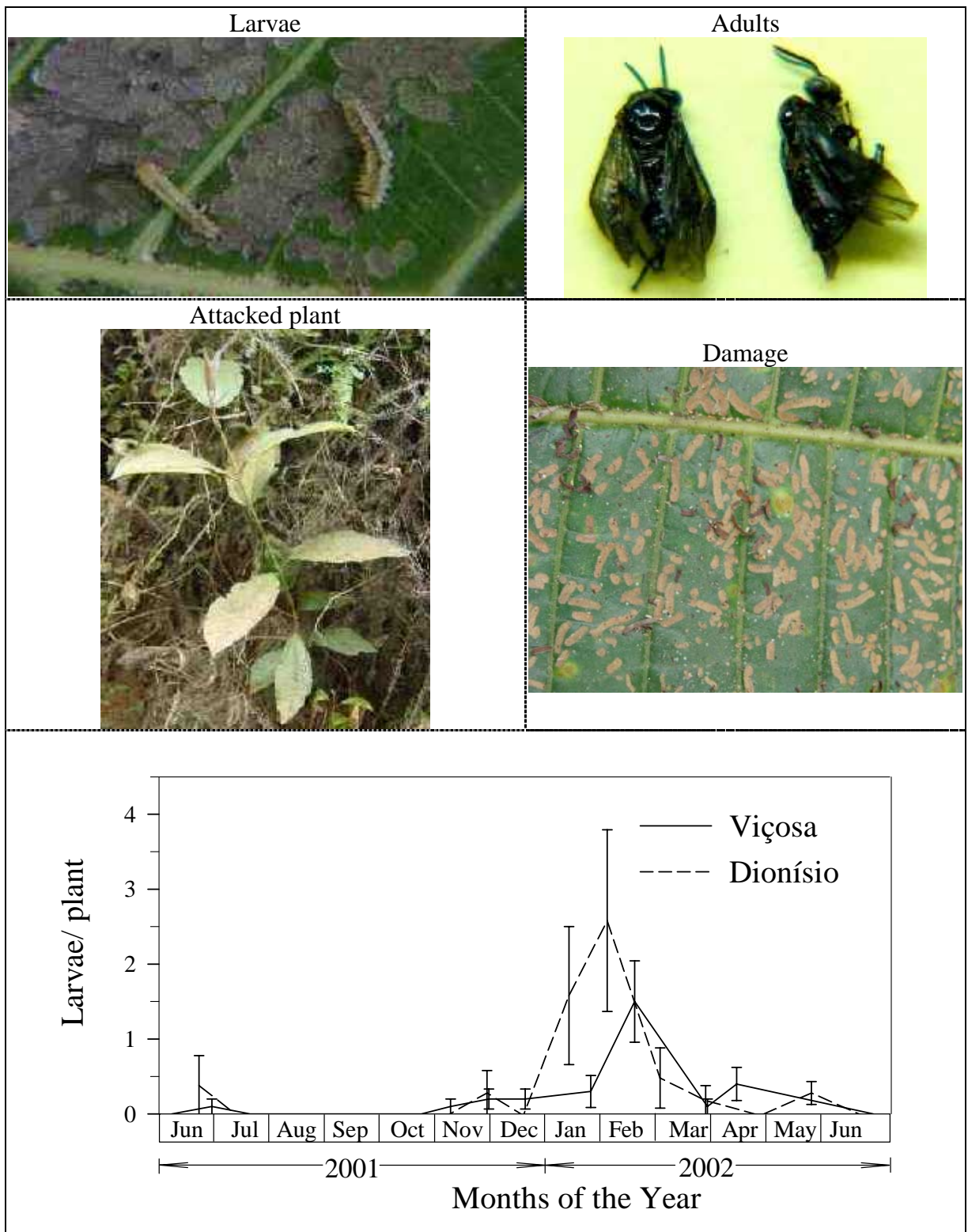


Fig. 13. Population density of larvae of *Atomacera petroa* (Hymenoptera: Argidae) on *Miconia calvenscens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

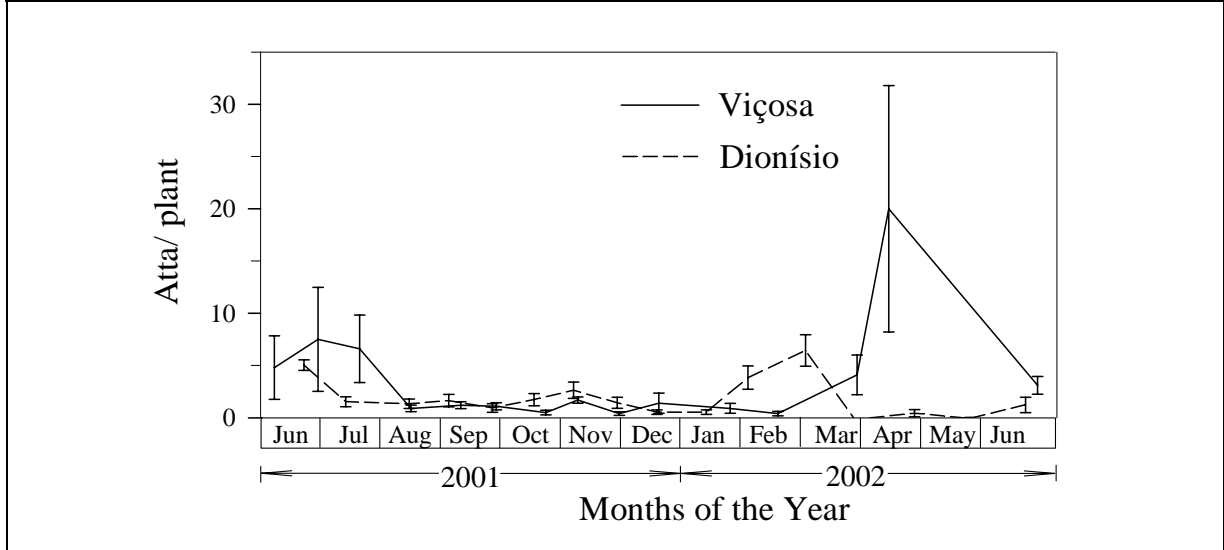


Fig. 14. Population density of *Atta sexdens rubropilosa* (Hymenoptera: Formicidae) on leaves of *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

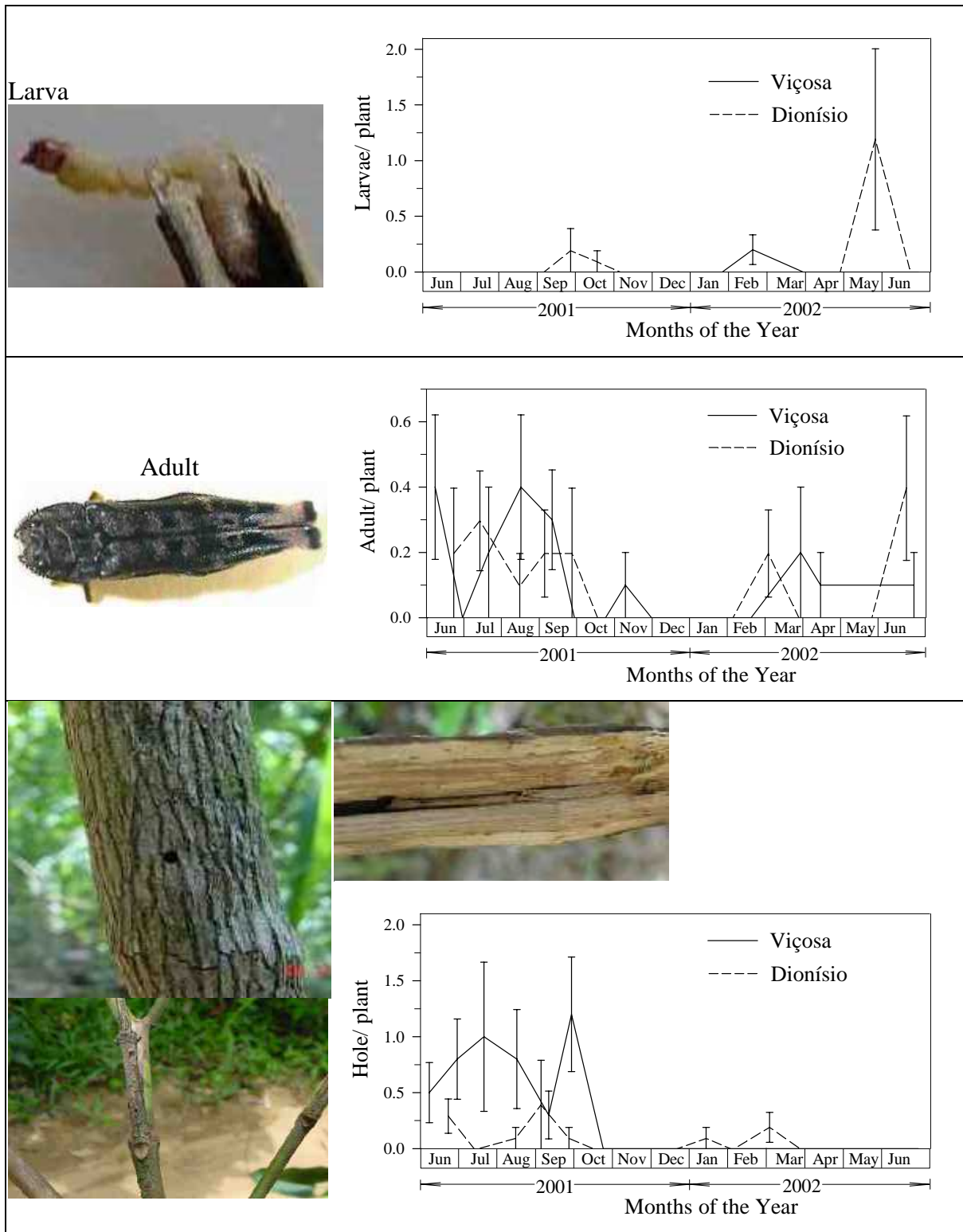


Fig. 15. *Agrilus* sp. (Coleoptera: Buprestidae) attack intensity on plants of *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.



Fig. 16. Adults of Coleoptera: Buprestidae collected at Itabira, Minas Gerais State. 2003.

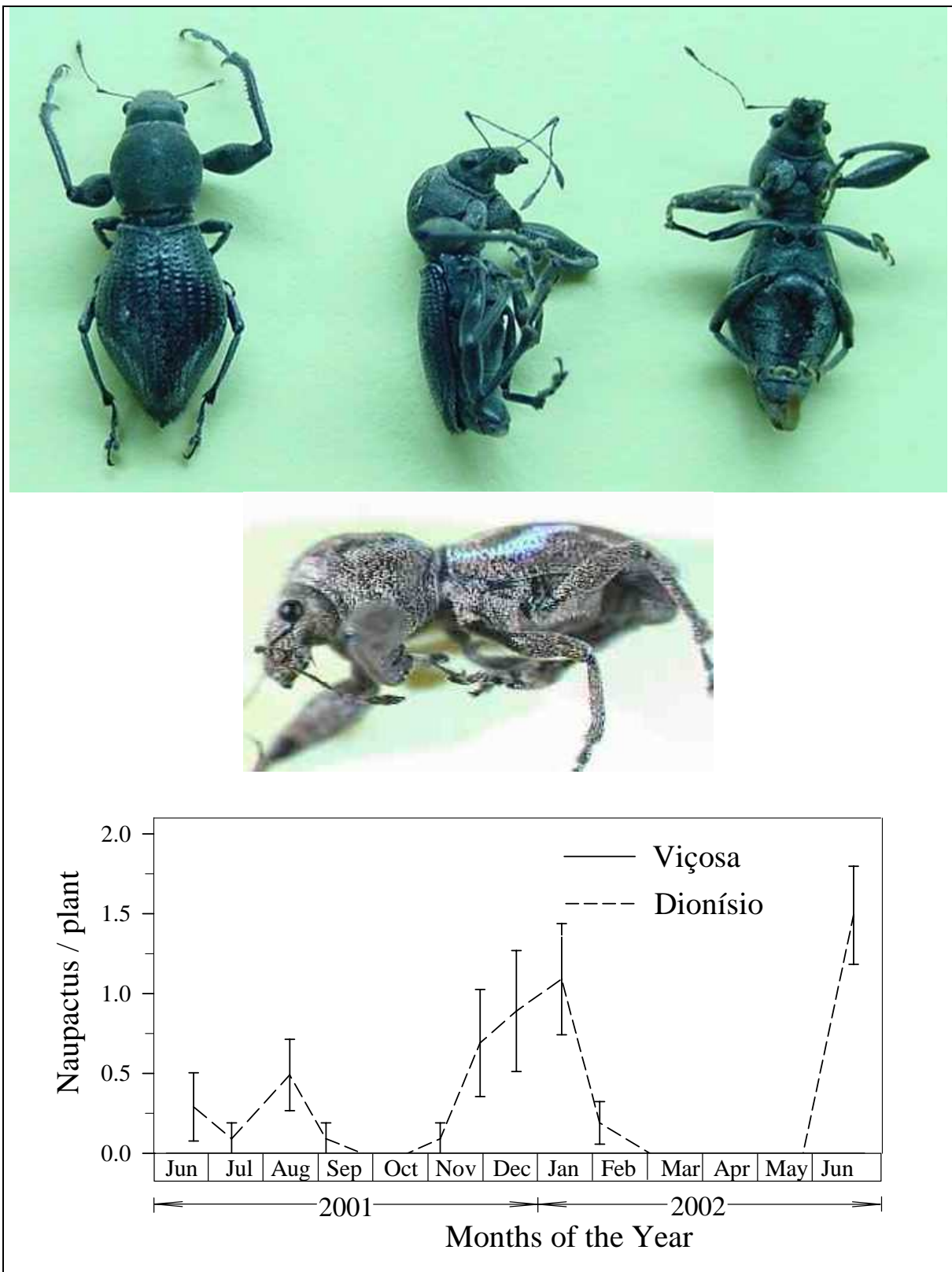


Fig. 17. Population density of two species of *Naupactus* spp. (Coleoptera: Curculionidae) on *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.

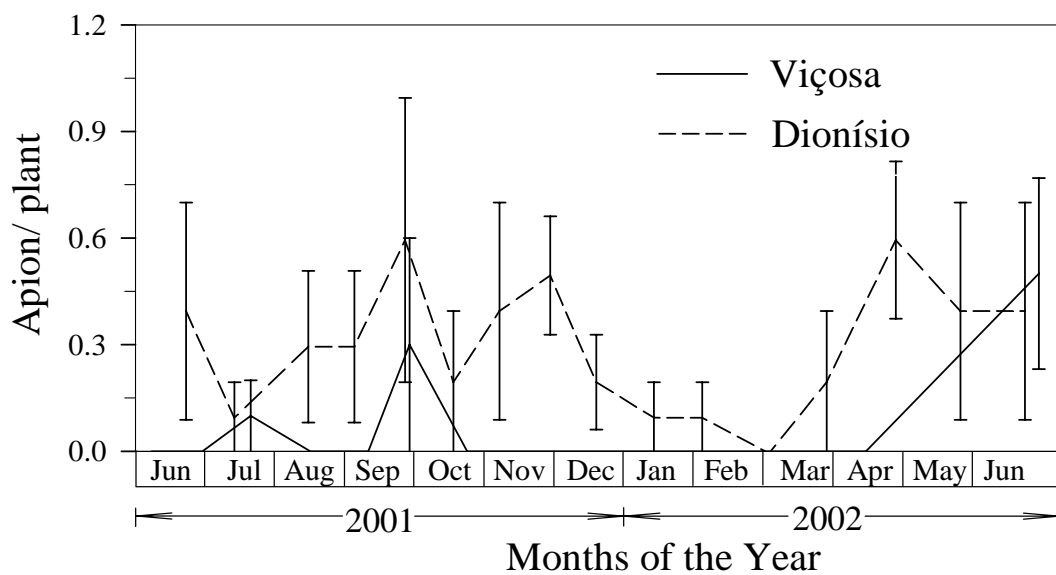


Fig. 18. Population density of *Apion* sp. (Coleoptera: Brentidae) on plants of *Miconia calvescens* at Dionísio and Viçosa, Minas Gerais State, Brazil. 2001/02. Bars = Standard error for the means.