

Spatial Distribution of Arthropods on *Acacia mangium* (Fabales: Fabaceae) Trees as Windbreaks in the Cerrado

Authors: F. W. S. Silva, G. L. D. Leite, R. E. M. Guanabens, R. A. Sampaio, C. A. G. Gusmão, et. al.

Source: Florida Entomologist, 97(2) : 631-638

Published By: Florida Entomological Society

URL: <https://doi.org/10.1653/024.097.0240>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

SPATIAL DISTRIBUTION OF ARTHROPODS ON ACACIA MANGIUM (FABALES: FABACEAE) TREES AS WINDBREAKS IN THE CERRADO

F. W. S. SILVA^{1,2*}, G. L. D. LEITE¹, R. E. M. GUANABENS¹, R. A. SAMPAIO¹, C. A. G. GUSMÃO¹ AND J. C. ZANUNCIO³
¹Institute of Agricultural Sciences, Universidade Federal de Minas Gerais, CEP: 39404-006, Montes Claros-MG, Brazil

²Department of Entomology, Universidade Federal de Viçosa, CEP: 36.570-900, Viçosa-MG, Brazil

³Department of Animal Biology, Universidade Federal de Viçosa, CEP: 36.570-900, Viçosa-MG, Brazil

*Corresponding author; E-mail: farley.silva@ufv.br

ABSTRACT

Acacia mangium (Fabales: Fabaceae) is broadly used in restoration process of degraded lands in tropical and subtropical regions. Thus, our aim was to assess the spatial distribution of arthropods on tree crown (vertical- upper, median and lower canopy and horizontal-north, south, east and west) and leaf surfaces (adaxial and abaxial) of *A. mangium* trees. Phytophagous arthropods and natural enemies were quantified biweekly in 20 trees during three years. The Shannon index (H') of phytophagous insects were higher on the abaxial surface of leaves on branches facing the west side and basal thirds, while the lowest index was found on the adaxial surface of leaves on branches facing north and on trunk of *A. mangium*. The natural enemies and pollinators presented the highest H' indexes on the abaxial surface of leaves on branches facing north on basal thirds of *A. mangium*, while the lowest index values were found on the adaxial surface of leaves on branches facing the other sides. *Trigona spinipes* Fabricius (Hymenoptera: Apidae, Meliponinae), *Aethalion reticulatum* (Hemiptera: Aetalionidae) and Pentatomidae sp.1 (Hemiptera) were the most abundant and with the lowest k -dominance on different parts of *A. mangium* trees. *Camponotus* sp.2 (Hymenoptera: Formicidae), *Tetragonisca angustula* (Latreille) (Hymenoptera: Apidae) and *Polistes* sp. (Hymenoptera: Vespidae) had higher abundance and lower k -dominance. These results may be a support for programs of pest control and maintenance of natural enemies and pollinators in future plantations of *A. mangium*. For instance, application of biopesticides may reach better results if aimed directly to the preferred sites of target organisms, beyond minimizing possible negative effects on non-target ones.

Key Words: canopy sampling, phytophagous, natural enemies, pollinators

RESUMEN

Acacia mangium (Fabales: Fabaceae) es ampliamente utilizado en el proceso de restauración de las tierras degradadas en las regiones tropicales y subtropicales. Por lo tanto, nuestro objetivo fue evaluar la distribución espacial de los artrópodos en la copa del árbol (vertical - dosel superior, medio e inferior y horizontal - norte, sur, este y oeste) y las superficies de las hojas (adaxial y abaxial) de *A. mangium*. Artrópodos fitófagos y enemigos naturales fueron cuantificados quincenalmente en 20 árboles durante tres años. El índice de Shannon (H') de los insectos fitófagos fueron más altos en la superficie abaxial de las hojas en las ramas que se enfrenta el lado oeste y tercios basales, mientras que se encontró el índice más bajo en la superficie adaxial de las hojas en las ramas que dan al norte y en el tronco de *A. mangium*. Los enemigos naturales y polinizadores presentan los más altos índices H' en la superficie abaxial de las hojas en las ramas que dan al norte en tercios basales de *A. mangium*, mientras que se encontraron los valores de los índices más bajos en la superficie adaxial de las hojas en las ramas que se enfrentan los otros lados. *Trigona spinipes* Fabricius (Hymenoptera: Apidae), *Aethalion reticulatum* (Hemiptera: Aetalionidae) y Pentatomidae sp.1 (Hemiptera) fueron las más abundantes y con el más bajo k -dominación en diferentes partes de *A. mangium*. *Camponotus* sp. 2 (Hymenoptera: Formicidae), *Tetragonisca angustula* (Latreille) (Hymenoptera: Apidae) y *Polistes* sp. (Hymenoptera: Vespidae) presentó mayor abundancia y más bajo k -dominación. Estos resultados pueden ser un apoyo para los programas de control de plagas y el mantenimiento de los enemigos naturales y polinizadores en las futuras plantaciones de *A. mangium*. Por ejemplo, la aplicación de biopesticidas puede alcanzar mejores resultados si dirigido directamente a los sitios preferidos de los organismos objetivo, más allá de minimizar los posibles efectos negativos en los que no va destinado.

Palabras Clave: canopy muestreo, fitófagos, enemigos naturales, polinizadores

The arboreal species *Acacia mangium* Willd. (Fabales: Fabaceae) is used in the initial succession and to restore degraded areas in tropical and subtropical regions (Yu & Li 2007; Phan Minh et al. 2013). This plant presents high potential for restoring or enhancing soil fertility by N-fixing and making fixed nitrogen and other plant nutrients available to other plants (Galiana et al. 1998).

Acacia mangium can also be used in windbreaks to prevent wind and water erosion and to improve environmental conditions (Brandle et al. 2004). A plant species used in windbreaks should be perennial, grow rapidly, but not be invasive nor excessively competitive, while having a dense crown for maximum efficiency and protection against erosion (Brandle et al. 2004; Norisada et al. 2005). These trees can be a barrier to the movement of herbivorous insects and to impede their capacity to locate their host plants (Rao et al. 2000). The plant canopy in a wind break offers great diversity of resources to maintain biodiversity, and their branches and leaves affect the environment by affecting humidity and evapotranspiration and by being refugia for birds and insects (Brandle et al. 2004).

Interactions between *Acacia* spp. plants and insects have been studied (Kruger & McGavin 1998; Fleming et al. 2007; Palmer et al. 2007) and insects are the main organisms responsible for the decline in Arabic gum production from these plants in Sudan (Jamal 1994). On the other hand, conversion of natural forests to *A. mangium* plantations has negatively impacted communities of insect groups, such as termites, ants, flies and beetles (Tsukamoto & Sabang 2005).

The aim of this study was to assess the spatial distribution of arthropods along the vertical canopy (apical, middle and basal parts and trunks),

horizontal orientation (branches facing north, south, east and west) and leaf surface (adaxial and abaxial) of *A. mangium* plants.

MATERIAL AND METHODS

Study Sites

This study was carried out in a pasture area of the Institute of Agricultural Sciences at the Universidade Federal de Minas Gerais (ICA/UFMG), Brazil. Samplings occurred from Jan 2005 to Mar 2007 in an area with Aw climate, i.e., tropical savanna according to the classification of Köppen with a dry winter and a rainy summer and a dystrophic red-yellow latosol.

Study Design

Windbreaks, 100 m long with 2 rows of *A. mangium* spaced 3 × 3 m were used. Seedlings of this species were prepared in a nursery and planted in Sep 2003 in 30 × 30 × 30 cm holes with 360 grams of natural reactive phosphate mixed into the subsoil of a *Brachiaria decumbens* Stapf. (Poales: Poaceae) pasture.

The phytophagous insects, natural enemies and pollinators insects in twenty 16-month old *A. mangium* trees were visually counted biweekly every yr. The arthropods were counted on the adaxial and abaxial leaf surfaces in the upper, median and lower apical canopy on branches facing north, south, east and west with a total of 12 leaves per canopy and nine per tree branch position in each sampling. Arthropod collection also occurred on the trunks of 20 trees per sampling. All material collected was stored in flasks with 70% ethanol, separated by morphospecies and sent for identification.

TABLE 1. SHANNON (H') BIODIVERSITY INDEXES OF PHYTOPHAGOUS AND NATURAL ENEMY ARTHROPODS ON *ACACIA MANGIUM* AS FUNCTIONS OF POSITIONS (CARDINAL POINTS) OF THE TREE'S BRANCHES, HEIGHTS WITHIN THE CANOPY AND UPPER OR LOWER LEAF SURFACES DURING THREE YEARS OF SAMPLING.

Index of Shannon (H')	Tree Branch Position on Trunk			
	North	South	East	West
Phytophagous	0.28	0.40	0.40	0.59
Natural enemies	0.84	0.76	0.76	0.76
Index of Shannon (H')	Canopy Height			
	Upper	Median	Lower	Trunk
Phytophagous	0.40	0.41	0.56	0.38
Natural enemies	0.70	0.76	0.78	0.39
Index of Shannon (H')	Leaf Surfaces			
	Abaxial (lower)		Adaxial (upper)	
Phytophagous	0.52		0.38	
Natural enemies	0.80		0.71	

TABLE 2. K-DOMINANCE AND ABUNDANCE VALUES (BETWEEN BRACKETS) OF PHYTOPHAGOUS AND NATURAL ENEMY ARTHROPODS ON ACACIA MANGIUM TREES AS FUNCTION OF LEAF SURFACES DURING THREE YEARS OF SAMPLING.

Phytophagous Arthropods	
Abaxial (lower) surface	Adaxial (upper) surface
<i>Trigona spinipes</i> Fabricius (Hymenoptera: Apidae)	<i>Aethalion reticulatum</i> L. (Hemiptera: Aetalionidae):
<i>Aethalion reticulatum</i> L. (Hemiptera: Aetalionidae)	<i>Trigona spinipes</i> Fabricius (Hymenoptera: Apidae)
Pentatomidae sp.1 (Hemiptera)	Pentatomidae sp.1 (Hemiptera)
<i>Diabrotica speciosa</i> Germar (Col.: Chrysomelidae)	Tettigoniidae (Orthoptera)
<i>Tropidacris collaris</i> Stoll (Orthoptera: Romaleidae)	<i>Tropidacris collaris</i> Stoll (Orthoptera: Romaleidae)
Coleoptera	<i>Dalbulus maidis</i> DeLong & Wolcott (Hom.: Cicadellidae)
Fulgoroidea (Hemiptera)	Fulgoroidea (Hemiptera)
<i>Mahanarva posticata</i> Stal (Homoptera: Cercopidae)	Lepidoptera
<i>Podalia</i> sp. (Lepidoptera: Megalopygidae)	<i>Mahanarva posticata</i> Stal (Homoptera: Cercopidae)
<i>Discodon</i> sp. (Coleoptera: Cantharidae)	<i>Diabrotica speciosa</i> Germar (Coleoptera: Chrysomelidae)
<i>Dalbulus maidis</i> DeLong & Wolcott (Homoptera: Cicadellidae)	Coleoptera
Lepidoptera	Pentatomidae sp.2 (Hemiptera)
Pentatomidae sp.2 (Hemiptera)	Membracidae (Hemiptera)
Membracidae (Hemiptera)	<i>Podalia</i> sp. (Lepidoptera: Megalopygidae)
<i>Euxesta</i> sp. (Diptera: Otitidae)	<i>Euxesta</i> sp. (Diptera: Otitidae)
Natural enemies and pollinators	
<i>Camponotus</i> sp.2 (Hymenoptera: Formicidae)	<i>Camponotus</i> sp.2 (Hymenoptera: Formicidae)
<i>Tetragonisca angustula</i> Latreille (Hym.: Meliponinae)	<i>Tetragonisca angustula</i> Latreille (Hym.: Meliponinae)
<i>Polistes</i> sp. (Hymenoptera: Vespidae)	<i>Musca domestica</i> Linnaeus (Diptera: Muscidae)
<i>Musca domestica</i> Linnaeus (Diptera: Muscidae)	<i>Polistes</i> sp. (Hymenoptera: Vespidae)
<i>Camponotus</i> sp.5 (Hymenoptera: Formicidae)	Chrysopidae (Neuroptera)
<i>Apis mellifera</i> L. (Hymenoptera: Apidae)	<i>Podisus</i> sp. (Hemiptera: Pentatomidae)
<i>Podisus</i> sp. (Hemiptera: Pentatomidae)	Araneidae
<i>Brachymyrmex</i> sp.1 (Hymenoptera: Formicidae)	<i>Aphirape uncinifera</i> Tullgren (Araneae: Salticidae)

TABLE 2. (CONTINUED) K-DOMINANCE AND ABUNDANCE VALUES (BETWEEN BRACKETS) OF PHYTOPHAGOUS AND NATURAL ENEMY ARTHROPODS ON *ACACIA MANGIUM* TREES AS FUNCTION OF LEAF SURFACES DURING THREE YEARS OF SAMPLING.

Phytophagous Arthropods		Abaxial (lower) surface	Adaxial (upper) surface
<i>Camponotus</i> sp.1 (Hymenoptera: Formicidae)	95.6 (8)		98.2 (1)
Araneidae	96.6 (7)		100 (1)
Lamprolidae (Coleoptera)	97.2 (4)		100 (0)
<i>Aphirape uncinifera</i> Tullgren (Araneae: Salticidae)	97.9 (4)		100 (0)
<i>Cephalotes</i> sp. (Hymenoptera: Formicidae)	98.3 (3)		100 (0)
<i>Episyrrhus balteatus</i> De Geer (Diptera: Syrphidae)	98.7 (3)		100 (0)
<i>Mantis religiosa</i> L. (Mantodea: Mantidae)	99.2 (3)		100 (0)
Dolichopodidae (Diptera)	99.5 (2)		100 (0)
Chrysopidae (Neuroptera)	99.7 (1)		100 (0)
<i>Chrysoperla externa</i> Hagen (Neur.: Chrysopidae)	99.8 (1)		100 (0)
<i>Oxyopes salticus</i> Hentz (Araneae: Oxyopidae)	100 (1)		100 (0)
<i>Mantis religiosa</i> L. (Mantodea: Mantidae)			98.2 (1)
<i>Cycloneda sanguinea</i> L. (Coleoptera: Coccinellidae)			100 (1)
Lamprolidae (Coleoptera)			100 (0)
<i>Apis mellifera</i> L. (Hymenoptera: Apidae)			100 (0)
Dolichopodidae (Diptera)			100 (0)
<i>Cephalotes</i> sp. (Hymenoptera: Formicidae)			100 (0)
<i>Episyrrhus balteatus</i> De Geer (Diptera: Syrphidae)			100 (0)
<i>Chrysoperla externa</i> Hagen (Neuroptera: Chrysopidae)			100 (0)
<i>Brachymyrmex</i> sp.2 (Hymenoptera: Formicidae)			100 (0)
<i>Oxyopes salticus</i> Hentz (Araneae: Oxyopidae)			100 (0)
<i>Camponotus</i> sp.5 (Hymenoptera: Formicidae)			100 (0)

Statistical Analysis

The ecological indexes (number of individuals, richness, diversity and abundance of species) were calculated for the arthropod species identified. All ecological indexes were measured by calculating the dataset of taxa by samples in BioDiversity Pro Version 2 software. Diversity was calculated by the Shannon-Weaver formula: $H = -\sum (p_i \ln p_i)$. Abundance and species richness (S) were calculated by the Simpson formula: $D = (\sum n_i^2 / N^2) * 100$, where: $p_i = n_i / N$; n_i = number of individuals per species; N = total number of individuals; S = richness (number of species present). k -Dominance were calculated by plotting the percentage cumulative abundance against log species rank (Lambshhead et al. 1983). The k -dominance values indicate the dominance and evenness distribution of individuals among species (Gee et al. 1985).

RESULTS AND DISCUSSION

Phytophagous arthropods presented their greatest biodiversity Shannon (H') index values on the abaxial (lower) leaf surfaces, on branches facing west, and in the lowest part of *A. mangium* canopies. In contrast, phytophagous arthropods presented the lowest H' values on the adaxial (upper) leaf surfaces, on branches facing north, and on the trunks of this plant (Table 1). The natural enemies and pollinators presented the greatest H' indexes on the abaxial surface of leaves on branches facing north on the lowest parts of *A. mangium*, while the lowest index values were found on the adaxial surface of leaves on branches facing the other directions (Table 1). It is likely that the preference of phytophagous arthropods for the above distributions in the canopy are related to a lower risk of parasitism (Ramanand & Olckers 2013) or predation by natural enemies, such as ants (Elbanna 2011). Furthermore, the presence of ants may attract pollinators (Gonzalez et al. 2013), which might explain the greatest abundance of both at the same sites.

The greatest abundance of *Trigona spinipes* Fabricius (Hymenoptera: Apidae, Meliponinae), *Aethalion reticulatum* L. (Hemiptera: Aetalionidae) and Pentatomidae sp.1 (Hemiptera) on the abaxial (lower) surface of leaves (Table 2) is likely owing to the biomechanical properties on this area. In general, densities of phytophagous insects are negatively correlated with work to tear and shear leaves (Peeters et al. 2007). Thus, it would be expected to find the greatest abundance of such insects on the abaxial surface of leaves where the epidermis is thinner, favoring insect feeding and, consequently, a higher fitness (Fiene et al. 2013).

The largest population of herbivorous insects on the abaxial leaf surfaces may attract arthropod natural enemies and pollinators, such as *Camponotus* sp.2 (Hymenoptera: Formicidae), *Tetragonisca*

TABLE 3. K-DOMINANCE AND ABUNDANCE VALUES (BETWEEN BRACKETS) OF PHYTOPHAGOUS AND NATURAL ENEMY ARTHROPODS ON *ACACIA MANGIUM* PLANTS AS A FUNCTION OF THE POSITION OF A TREE BRANCH RELATIVE TO THE CARDINAL POINTS DURING THREE YEARS OF SAMPLING.

Phytophagous Arthropods		North		South		East		West	
<i>Trigona spinipes</i>	91.4 (53)	<i>Trigona spinipes</i>	51.4 (74)	<i>Trigona spinipes</i>	53.1 (137)	<i>Trigona spinipes</i>	39.7 (60)	<i>Trigona spinipes</i>	39.7 (60)
<i>Diabrotica speciosa</i>	94.8 (2)	<i>A. reticulatum</i>	95.1 (63)	<i>A. reticulatum</i>	96.1 (111)	Pentatomidae sp.1	73.5 (51)	Pentatomidae sp.1	73.5 (51)
<i>Tropidacris colaris</i>	96.6 (1)	<i>Diabrotica speciosa</i>	97.2 (3)	Coleoptera	96.9 (2)	<i>A. reticulatum</i>	92.7 (29)	<i>A. reticulatum</i>	92.7 (29)
Tettigoniidae	98.3 (1)	<i>Discodon</i> sp.	98.6 (2)	<i>T. colaris</i>	97.3 (1)	<i>Tropidacris colaris</i>	94.7 (3)	<i>Tropidacris colaris</i>	94.7 (3)
<i>Podalia</i> sp.	100 (0)	<i>Tropidacris colaris</i>	99.3 (1)	<i>Dalbulus maidis</i>	97.6 (1)	Coleoptera	96.7 (3)	Coleoptera	96.7 (3)
<i>A. reticulatum</i>	100 (0)	<i>M. posticata</i>	100 (1)	Fulgoroidea	98.0 (1)	<i>Diabrotica speciosa</i>	98.0 (2)	<i>Diabrotica speciosa</i>	98.0 (2)
Pentatomidae sp.1	100 (0)	Pentatomidae ¹	100 (0)	Lepidoptera	98.4 (1)	Fulgoroidea	98.6 (1)	Fulgoroidea	98.6 (1)
<i>Dalbulus maidis</i>	100 (0)	<i>Dalbulus maidis</i>	100 (0)	<i>M. posticata</i>	98.8 (1)	Pentatomidae sp.2	99.3 (1)	Pentatomidae sp.2	99.3 (1)
Fulgoroidea	100 (0)	Fulgoroidea	100 (0)	<i>D. speciosa</i>	99.2 (1)	Membracidae	100 (1)	Membracidae	100 (1)
Lepidoptera	100 (0)	Lepidoptera	100 (0)	<i>Podalia</i> sp.	99.6 (1)	<i>Dalbulus maidis</i>	100 (0)	<i>Dalbulus maidis</i>	100 (0)
<i>M. posticata</i>	100 (0)	Tettigoniidae	100 (0)	<i>Euxesta</i> sp.	100 (1)	Lepidoptera	100 (0)	Lepidoptera	100 (0)
Natural enemies and pollinators									
<i>T. angustula</i>	34.6 (44)	<i>Camponotus</i> sp.2	42.6 (58)	<i>Camponotus</i> sp.2	43.1 (93)	<i>Camponotus</i> sp.2	42.5 (102)	<i>Camponotus</i> sp.2	42.5 (102)
<i>Camponotus</i> sp.2	62.2 (35)	<i>T. angustula</i>	61.0 (25)	<i>T. angustula</i>	68.5 (55)	<i>T. angustula</i>	62.5 (48)	<i>T. angustula</i>	62.5 (48)
<i>Musca domestica</i>	70.9 (11)	<i>Polistes</i> sp.	72.7 (16)	<i>Polistes</i> sp.	77.3 (19)	<i>Polistes</i> sp.	78.7 (39)	<i>Polistes</i> sp.	78.7 (39)
<i>Polistes</i> sp.	78.7 (10)	<i>Camponotus</i> sp.5	81.6 (12)	<i>Camponotus</i> sp.5	83.3 (13)	<i>Musca domestica</i>	85.0 (15)	<i>Musca domestica</i>	85.0 (15)
<i>Podisus</i> sp.	82.7 (5)	<i>Musca domestica</i>	89.7 (11)	<i>Musca domestica</i>	88.4 (11)	<i>Apis mellifera</i>	87.5 (6)	<i>Apis mellifera</i>	87.5 (6)
<i>Apis mellifera</i>	85.8 (4)	<i>Apis mellifera</i>	94.1 (6)	<i>Apis mellifera</i>	92.1 (8)	<i>Brachymyrmex</i> sp.1	90.0 (6)	<i>Brachymyrmex</i> sp.1	90.0 (6)
<i>Brachymyrmex</i> sp.1	89.0 (4)	<i>Podisus</i> sp.	96.3 (3)	<i>Camponotus</i> sp.1	93.9 (4)	<i>Podisus</i> sp.	92.5 (6)	<i>Podisus</i> sp.	92.5 (6)
Chrysopidae	91.3 (3)	<i>Episyrrhus balteatus</i>	97.1 (1)	<i>E. balteatus</i>	94.9 (2)	Araeidae	94.5 (5)	Araeidae	94.5 (5)
<i>Camponotus</i> sp.5	93.7 (3)	<i>Chrysoperla externa</i>	97.7 (1)	<i>Podisus</i> sp.	95.8 (2)	Lamyridae	96.2 (4)	Lamyridae	96.2 (4)
Araeidae	95.3 (2)	Araeidae	98.5 (1)	<i>Aphirape uncinifera</i>	96.8 (2)	<i>Camponotus</i> sp.1	97.5 (3)	<i>Camponotus</i> sp.1	97.5 (3)
<i>Aphirape uncinifera</i>	96.8 (2)	<i>Aphirape uncinifera</i>	99.2 (1)	Dolichopodidae	97.2 (1)	<i>Cephalotes</i> sp.	98.7 (3)	<i>Cephalotes</i> sp.	98.7 (3)
Lamyridae	97.6 (1)	<i>Mantis religiosa</i>	100 (1)	<i>Cephalotes</i> sp.	97.6 (1)	<i>Mantis religiosa</i>	99.5 (2)	<i>Cephalotes</i> sp.	99.5 (2)
Dolichopodidae	98.4 (1)	Lamyridae	100 (0)	Chrysopidae	98.1 (1)	<i>Mantis religiosa</i>	100 (1)	<i>Mantis religiosa</i>	100 (1)
<i>Mantis religiosa</i>	99.2 (1)	Dolichopodidae	100 (0)	Araeidae	98.6 (1)	Dolichopodidae	100 (0)	Dolichopodidae	100 (0)
<i>Camponotus</i> sp.1	100 (1)	<i>Cephalotes</i> sp.	100 (0)	<i>Oxyopes salticus</i>	99.0 (1)	Chrysopidae	100 (0)	Chrysopidae	100 (0)
<i>Cephalotes</i> sp.	100 (0)	Chrysopidae	100 (0)	<i>Mantis religiosa</i>	99.5 (1)	<i>E. balteatus</i>	100 (0)	<i>E. balteatus</i>	100 (0)
<i>E. balteatus</i>	100 (0)	<i>Brachymyrmex</i> sp.1	100 (0)	<i>C. sanguinea</i>	100 (1)	<i>C. externa</i>	100 (0)	<i>C. externa</i>	100 (0)

TABLE 4. K-DOMINANCE AND ABUNDANCE VALUES (BETWEEN BRACKETS) OF PHYTOPHAGOUS AND NATURAL ENEMY ARTHROPODS ON ACACIA MANGIUM TREES AS FUNCTION OF THE HEIGHT WITHIN THE CANOPY DURING THREE YEARS OF SAMPLING.

Phytophagous			
Upper Canopy	Median Canopy	Lower Canopy	Trunk
<i>A. reticulatum</i>	<i>T. spinipes</i>	<i>Trigona spinipes</i>	<i>Aethalion reticulatum</i>
49.6 (63)	63.5 (134)	48.1 (132)	58.7 (121)
<i>Trigona spinipes</i>	<i>A. reticulatum</i>	<i>A. reticulatum</i>	<i>Trigona spinipes</i>
95.3 (58)	93.3 (63)	76.3 (77)	95.1 (75)
<i>Fulgoroidea</i>	<i>D. speciosa</i>	Pentatomidae sp.1	Homoptera
96.8 (2)	96.6 (7)	94.5 (50)	97.5 (5)
<i>M. posticata</i>	Pentatomidae ¹	<i>Tropidacris colaris</i>	Membracidae
98.4 (2)	97.2 (1)	95.9 (4)	98.5 (2)
<i>Tropidacris colaris</i>	<i>Tropidacris colaris</i>	Coleoptera	<i>Quesada gigas</i>
99.2 (1)	97.6 (1)	97.4 (4)	99.5 (2)
<i>Podalia</i> sp.	Lepidoptera	<i>Discodon</i> sp.	<i>Tropidacris colaris</i>
100 (1)	98.1 (1)	98.1 (2)	100 (1)
Pentatomidae sp.1	Coleoptera	<i>Dalbulus maidis</i>	Pentatomidae sp.1
100 (0)	98.6 (1)	98.5 (1)	100 (0)
<i>Dalbulus maidis</i>	Pentatomidae sp.2	<i>M. posticata</i>	<i>Dalbulus maidis</i>
100 (0)	99.0 (1)	98.9 (1)	100 (0)
Lepidoptera	Membracidae	Tettigoniidae	Fulgoroidea
100 (0)	100 (0)	99.3 (1)	100 (0)
Tettigoniidae	<i>Podalia</i> sp.	<i>D. speciosa</i>	Lepidoptera
100 (0)	100 (1)	99.6 (1)	100 (0)
<i>D. speciosa</i>	<i>D. maidis</i>	100 (0)	<i>Mahanara posticata</i>
100 (0)	100 (0)	100 (1)	100 (0)
Natural enemies and pollinators			
<i>T. angustula</i>	<i>Camponotus</i> sp.2	<i>Camponotus</i> sp.2	<i>Camponotus</i> sp.2
54.3 (69)	40.9 (137)	50.9 (131)	73.4 (58)
<i>Camponotus</i> sp.2	<i>T. angustula</i>	<i>T. angustula</i>	<i>Podisus</i> sp.
70.1 (20)	62.1 (71)	63.4 (32)	86.1 (10)
<i>Camponotus</i> sp.5	<i>Polistes</i> sp.	<i>Polistes</i> sp.	<i>Camponotus</i> sp.5
76.4 (8)	77.9 (53)	73.1 (25)	94.9 (7)
<i>Musca domestica</i>	<i>M. domestica</i>	<i>Musca domestica</i>	<i>T. angustula</i>
81.1 (6)	84.5 (22)	80.9 (20)	97.5 (2)
<i>Polistes</i> sp.	<i>Camponotus</i> sp.5	84.4 (9)	<i>Musca domestica</i>
85.8 (6)	89.5 (17)	87.2 (7)	98.7 (1)
<i>Brachymyrmex</i> sp.1	<i>Apis mellifera</i>	<i>Camponotus</i> sp.1	<i>Camponotus</i> sp.1
90.5 (6)	93.7 (14)	89.4 (6)	100 (1)
<i>Apis mellifera</i>	<i>Podisus</i> sp.	<i>Podisus</i> sp.	Lampyridae
94.5 (5)	95.8 (7)	91.4 (5)	100 (0)
<i>Podisus</i> sp.	Araneidae	<i>Apis mellifera</i>	<i>Apis mellifera</i>
96.0 (2)	Lampyridae	Chrysopidae	100 (0)
Araneidae	Lampyridae	Polistes sp.	100 (0)
97.6 (2)	<i>A. uncifera</i>	Polistes sp.	100 (0)
Lampyridae	<i>M. religiosa</i>	Dolichopodidae	100 (0)
98.4 (1)	<i>Brachymyrmex</i> sp.1	94.1 (3)	100 (0)
Lampyridae	<i>O. Salticus</i>	95.3 (3)	100 (0)
99.2 (1)	<i>Camponotus</i> sp.1	96.5 (3)	100 (0)
<i>Aphirape uncifera</i>	<i>C. sanguinea</i>	97.3 (2)	100 (0)
100 (1)	Dolichopodidae	98.0 (2)	100 (0)
<i>Mantis religiosa</i>	<i>Camponotus</i> sp.1	98.8 (2)	100 (0)
100 (0)	<i>C. sanguinea</i>	99.2 (1)	100 (0)
Dolichopodidae	<i>Chrysopidae</i>	99.6 (1)	100 (0)
100 (0)	<i>Oxyopes salticus</i>	100 (1)	100 (0)
<i>Cephalotes</i> sp.	<i>Chrysopidae</i>	100 (0)	100 (0)
100 (0)	<i>Chrysopidae</i>	100 (0)	100 (0)
<i>E. balteatus</i>	<i>Chrysopidae</i>	100 (0)	100 (0)
100 (0)	<i>Chrysopidae</i>	100 (0)	100 (0)
<i>C. externa</i>	<i>Chrysopidae</i>	100 (0)	100 (0)
100 (0)	<i>Chrysopidae</i>	100 (0)	100 (0)
<i>Oxyopes salticus</i>	<i>Chrysopidae</i>	100 (0)	100 (0)

angustula (Latreille) (Hymenoptera: Apidae) and *Polistes* sp. (Hymenoptera: Vespidae) (Table 2). The greatest biodiversity of phytophagous arthropods and the natural enemies *Camponotus* sp.2, *Polistes* sp. and *Podisus* sp. (Hemiptera: Pentatomidae) on the west side of the canopy of *A. mangium* (Table 3) may be explained by the lowest impact of predominant wind currents from northeast/east in this region (Leite et al. 2006). Furthermore, parts of plants more exposed to winds may present thicker leaves owing to dehydration, which reduces feeding preference by phytophagous insects. Changes in the microclimate of arboreal systems increase air humidity and decrease the temperature and wind speed with positive effects on insect development (Rao et al. 2000). The quality of food resources may explain the greatest abundance of the bees, *T. spinipes* and *T. angustula*, on the east side of the canopy of *A. mangium* (Table 3) because leaves exposed to wind currents may present a higher evaporation, and thus increased nectar concentration in flowers (deBruijn & Sommeijer 1997).

The phytophagous *T. spinipes* and Hemiptera were most abundant in the median and lower level canopy of *A. mangium*, respectively (Table 4), sites where leaves are likely older than on upper canopy. Older leaves are less chemically defended than young ones, which may favor the herbivory (Alba et al. 2013). Furthermore, the lower canopy may present higher humidities and lower temperatures (Rao et al. 2000), decreasing insect desiccation (Rao et al. 2000) and improving survival conditions. The same protecting factors against desiccation might have influenced the natural enemies *Camponotus* sp.2, *T. angustula* and *Polistes* sp., which were more abundant in the median than in the upper canopy and trunks of *A. mangium* trees, respectively (Table 4).

The lowest *k*-dominance and greatest abundance values of *T. spinipes*, *A. reticulatum* and Pentatomidae sp.1 on different *A. mangium* parts without damaging leaves and flowers of this tree agrees with that reported for Hemiptera with greater number of species on the canopy of *Acacia* spp. (Kruger & McGavin 1998). These insects are harmful to several plant cultures, being responsible for damaging sprouts for removal of fibers to construct their nests (Boica et al. 2004). *Aethalion reticulatum* sucks sap which affects fruit development and sprouting, beyond killing plants at high infestations (Brown 1976).

The natural enemies *Camponotus* sp.2 and *Polistes* sp. and the pollinator *T. angustula* were the most abundant and with the lowest *k*-dominance. *Camponotus* spp. are, in general, associated with sucking insects (Fernandes et al. 2005) such as *A. reticulatum* (Brown 1976), protecting them against predators and parasitoids (Renault et al. 2005), which explains their great abundance on *A. mangium* trees. Therefore, *Camponotus*

spp. can indirectly affect host plants by hindering natural enemies impact. However, *T. angustula* is important for dispersing pollen and increasing plant genetic variability (Próni & Macieira 2004).

The potential of soil restoration or improvement by *A. mangium* trees in agroforestry systems can be explained by its benefit on soil structure and fertility due to N-fixing and increasing organic matter (Garay et al. 2003). *Acacia mangium* improves the conditions for the soil fauna, including earthworms (Pellens & Garay 1999; Tsukamoto & Sabang 2005) and for the commensalism between *Pseudomyrmex* spp. (Hymenoptera: Formicidae) and birds on this plant (de Ita and Rojas-Soto 2006). The ant presence can improve bird reproduction by reducing predation on their nests, whereas *Acacia* trees can supply branches, leaves and other materials for the nest building (Ndithia et al. 2007).

In conclusion, organisms, including phytophagous insects, natural enemies and pollinators presented the greatest diversities on the abaxial surface of leaves located on lower parts of the canopy of *A. mangium*. With regards to the canopy side, phytophagous insects presented a greater diversity on the west side, while natural enemies and pollinators presented a greater diversity on the north side. These results may support for programs of pest control and maintenance of natural enemies and pollinators in future plantations of *Acacia mangium*. For instance, application of biopesticides may reach better results if aimed directly to the preferred sites of target organisms, beyond minimizing possible negative effects on non-target ones.

ACKNOWLEDGMENTS

To the taxonomistas “Drs. Antônio Domingos Brescovit (Instituto Butantã) (Arachnida), Ayr de Moura Bello (Coleoptera), Ivan Cardoso Nascimento (EMBRAPA-ILHEUS-Centro de Pesquisas do Cacau, CEPAC, Itabuna, BA) (Formicidae), Paulo Sérgio Fiuza Ferreira (Hemiptera) (UFV) e Luci Boa Nova Coelho (Universidade Federal do Rio de Janeiro (Cicadellidae)” for identifying the insects. To Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and “Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG).

REFERENCES CITED

- ALBA, C., PRIORESCHI, R., AND QUINTERO, C. 2013. Population and leaf-level variation of iridoid glycosides in the invasive weed *Verbascum thapsus* L. (common mullein): implications for herbivory by generalist insects. *Chemoecology* 23: 83-92.
- BOICA, A. L., DOS SANTOS, T. M., AND PASSILONGO, J. 2004. *Trigona spinipes* (Fabr.) (Hymenoptera : Apidae) in passion fruit species: Seasonal fluctuation, visitation time and flower damage. *Neotrop. Entomol.* 33: 135-139.

- BRANDLE, J. R., HODGES, L., AND ZHOU, X. H. 2004. Windbreaks in North American agricultural systems. *Agrofor. Syst.* 61-2: 65-78.
- BROWN, R. L. 1976. Behavioral observations on *Aethalion reticulatum* (Hem. Aethalionidae) and associated ants. *Insectes Soc.* 23: 99-107.
- DE ITA, A. O., AND ROJAS-SOTO, O. R.. 2006. Ant presence in acacias: an association that maximizes nesting success in birds? *Wilson J. Ornithol.* 118: 563-566.
- DEBRULJN, L. L. M., AND SOMMEIJER, M. J. 1997. Colony foraging in different species of stingless bees (Apidae, Meliponinae) and the regulation of individual nectar foraging. *Insectes Soc.* 44: 35-47.
- ELBANNA, S. M. 2011. Ant-Acacia interaction: Chemical or physical defense? *Entomol. Res.* 41: 135-141.
- FERNANDES, G. W., FAGUNDES, M., GRECO, M. K. B., BARBEITOS, M. S., AND SANTOS, J. C. 2005. Ants and their effects on an insect herbivore community associated with the inflorescences of *Byrsonima crassifolia* (Linnaeus) HBK (Malpighiaceae). *Rev. Bras. Entomol.* 49: 264-269.
- FIENE, J., KALNS, L., NANSSEN, C., BERNAL, J., HARRIS, M., AND SWORD, G. A. 2013. Foraging on individual leaves by an intracellular feeding insect is not associated with leaf biomechanical properties or leaf orientation. *Plos One* 8.
- FLEMING, P. A., HOFMEYR, S. D., AND NICOLSON, S. W. 2007. Role of insects in the pollination of *Acacia nigrescens* (Fabaceae). *S. African J. Bot.* 73: 49-55.
- GALIANA, A., GNAHOUA, G. M., CHAUMONT, J., LESUEUR, D., PRIN, Y., AND MALLET, B. 1998. Improvement of nitrogen fixation in *Acacia mangium* through inoculation with rhizobium. *Agrofor. Syst.* 40: 297-307.
- GARAY, I., KINDEL, A., CARNEIRO, R., FRANCO, A. A., BARROS, E., AND ABBADIE, L. 2003. Comparison of organic matter and other soil properties in *Acacia mangium* and *Eucalyptus grandis* plantations. *Rev. Bras. Ciênc. Solo* 27: 705-712.
- GEE, J. M., WARWICK, R. M., SCHAANNING, M., BERGE, J. A., AND AMBROSE, W. G. 1985. Effects of organic enrichment on meiofaunal abundance and community structure in sublittoral soft sediments. *J. Exp. Mar. Biol. Ecol.* 91: 247-262.
- GONZALVEZ, F. G., SANTAMARIA, L., CORLETT, R. T., AND RODRIGUEZ-GIRONES, M. A. 2013. Flowers attract weaver ants that deter less effective pollinators. *J. Ecol.* 101: 78-85.
- JAMAL, A. 1994. Major insect pests of gum arabic trees *Acacia senegal* Willd and *Acacia seyal* L in Western Sudan. *J. Appl. Entomol.* 117: 10-20.
- KRUGER, O., AND MCGAVIN, G. C. 1998. Insect diversity of *Acacia* canopies in Mkomazi game reserve, north-east Tanzania. *Ecography* 21: 261-268.
- LAMBSHEAD, P. J. D., PLATT, H. M., AND SHAW, K. M. 1983. The detection of differences among assemblages of marine benthic species based on an assessment of dominance and diversity. *J. Nat. Hist.* 17: 859-874.
- LEITE, G. L. D., VELOSO, R. V. D. S., ZANUNCIO, J. C., FERNANDES, L. A., AND ALMEIDA, C. I. M. 2006. Phenology of *Caryocar brasiliense* in the Brazilian cerrado region. *For. Ecol. Manage.* 236: 286-294.
- NDITHIA, H., PERRIN, M. R., AND WALTERT, M. 2007. Breeding biology and nest site characteristics of the rosy-faced lovebird *Agapornis roseicollis* in Namibia. *Ostrich* 78: 13-20.
- NORISADA, M., HITSUMA, G., KURODA, K., YAMANOSHITA, T., MASUMORI, M., TANGE, T., YAGI, H., NUYIM, T., SASAKI, S., AND KOJIMA, K. 2005. *Acacia mangium*, a nurse tree candidate for reforestation on degraded sandy soils in the Malay Peninsula. *For. Sci.* 51: 498-510.
- PALMER, W. A., LOCKETT, C. J., SENARATNE, K. A. D. W., AND MCLENNAN, A. 2007. The introduction and release of *Chiasmia inconspicua* and *C. assimilis* (Lepidoptera: Geometridae) for the biological control of *Acacia nilotica* in Australia. *Biol. Control* 41: 368-378.
- PEETERS, P. J., SANSON, G., AND READ, J. 2007. Leaf biomechanical properties and the densities of herbivorous insect guilds. *Funct. Ecol.* 21: 246-255.
- PELLENS, R., AND GARAY, I. 1999. Edaphic macroarthropod communities in fast-growing plantations of *Eucalyptus grandis* Hill ex Maid (Myrtaceae) and *Acacia mangium* Wild (Leguminosae) in Brazil. *Eur. J. Soil Biol.* 35: 77-89.
- PHAN MINH, S., LAMB, D., BONNER, M., AND SCHMIDT, S. 2013. Carbon sequestration and soil fertility of tropical tree plantations and secondary forest established on degraded land. *Plant Soil* 362: 187-200.
- PRONI, E. A., AND MACIEIRA, O. J. D. 2004. Circadian rhythm of the respiratory rate of *Tetragonisca angustula fiebrigi* (Schwarz), *T. a. angustula* (Latreille) and *Trigona spinipes* (Fabricius) (Hymenoptera, Apidae, Meliponinae). *Rev. Bras. Zool.* 21: 987-993.
- RAMANAND, H., AND OLCKERS, T. 2013. Does height of exposure in the canopy influence egg mortality in *Acanthoscelides macrophthalmus* (Coleoptera: Chrysomelidae), a biological control agent of *Leucaena leucocephala* in South Africa? *Biocontrol Sci. Technol.* 23: 545-554.
- RAO, M. R., SINGH, M. P., AND DAY, R. 2000. Insect pest problems in tropical agroforestry systems: Contributory factors and strategies for management. *Agrofor. Syst.* 50: 243-277.
- RENAULT, C. K., BUFFA, L. M., AND DELFINO, M. A. 2005. An aphid-ant interaction: effects on different trophic levels. *Ecol. Res.* 20: 71-74.
- TSUKAMOTO, J., AND SABANG, J. 2005. Soil macro-fauna in an *Acacia mangium* plantation in comparison to that in a primary mixed dipterocarp forest in the lowlands of Sarawak, Malaysia. *Pedobiologia* 49: 69-80.
- YU, H., AND LI, J. T. 2007. Physiological comparisons of true leaves and phyllodes in *Acacia mangium* seedlings. *Photosynthetica* 45: 312-316.