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*Full Length Research Paper*

# Effect of canopy height and surface leaf on arthropods in medicinal plants

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**The objective of this work was to study the distribution of arthropods in the canopy height and leaf surface of different medicinal plants. We observed a higher number of herbivorous insects in the apical leaves of medicinal plants such as *Aphis gossypii* Glover (Hemiptera: Aphididae) in *Taraxacum officinale*, *Foeniculum vulgare*, *Artemisia absinthium*, and *Mentha arvensis*; *Empoasca* sp. (Hemiptera: Cicadellidae) in *Mentha x villosa* and *Origanum vulgare*; *Frankliniella* sp. (Thysanoptera: Thripidae) in *Calendula officinalis*; *Lagria villosa* Fabr. (Coleoptera: Lagriidae) in *A. absinthium*, *Achillea millefolium*, and *Plantago major*; *Leptoglossus* sp. (Hemiptera: Coreidae) in *Ocimum gratissimum* and *C. officinalis*; *Sistena* sp. (Coleoptera: Chrysomelidae) in *C. officinalis* and *P. major*; *Trigona spinipes* Fabr. (Hymenoptera: Apidae) in *Ocimum basilicum* and *Passiflora* sp.1 and *Uroleucon ambrosiae* (Thomas) f. *lizerianum* (E. E. Blanchard) (Hemiptera: Aphididae) in *C. officinalis*. While in *Symphytum officinale*, *Empoasca* sp. preferred to attack the middle part of the canopy and *Liriomyza* sp. in *Cotyledon orbiculata*. It was noted the higher presence herbivorous insects on the abaxial face of leaves of the medicinal plantas such as *A. gossypii* in *T. officinale*, *F. vulgare*, and *A. absinthium*; *Empoasca* sp. in *M. x villosa*, *O. gratissimum*, *Ocimum selloi*, *Solidago chilensis*, *S. officinale*, and *Thymus vulgaris*; *Frankliniella* sp., *U. ambrosiae* f. *lizerianum*, and *Leptoglossus* sp. in *C. officinalis*; *Liriomyza* sp. in *C. orbiculata*; *Coccus* sp. (Hemiptera: Coccidae) in *F. vulgare*; *Deois flavopicta* (Stal) and *Zulia entreriana* (Berg) (Hemiptera: Cercopidae) in *Cymbopogon citratus*, *Diabrotica speciosa* Germ. (Coleoptera: Chrysomelidae) in *S. officinale* and *F. vulgare*; *L. villosa* in *S. officinale* and *F. vulgare*; *Sistena* sp. (Coleoptera: Chrysomelidae) in *C. officinalis*, *M. x villosa*, and *S. officinale*; *T. spinipes* in *O. basilicum*; and *Xyleus* sp. (Orthoptera: Acrididae) in *S. officinale*, *A. absinthium*, and *Plectranthus barbatus*. However, in *Acmella oleracea*, *Coccus* sp. preferentially attacked the upper face of the leaves.**

**Key words:** Insecta, fitotherapics, Dossel distribution.

## INTRODUCTION

The high cost of synthetic medicines, their side effects, the poor health care system, and other factors, make most of the world population to still use plants for therapeutic purposes. Only 20% of Brazilian population consumes 63% of synthetic drugs, and the rest uses natural products, especially vegetables, as a therapeutic resource (Martins and Santos, 1995; Reis and Mariot, 2000). It has been a recommended practice, in many countries, the organic cultivation of medicinal plants. The reasons for the organic cultivation of medicinal herbs are various, being the most common the emphasis on the benefits of using organic manure as well as the

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management of pests without using pesticides (Martins et al., 1994).

For this purpose, besides knowing the pest species and beneficial insects that are associated with the cultivation of medicinal plants, it is necessary to know how the pest species are distributed along the canopy of plants, to help in selecting the best tactical control (Dent, 1995). However, there are few studies published in Brazil and in the World in this regard (Leite et al., 2005a, 2007, 2008; Silva et al., 2009). A large part of national and international papers dealing with insects on medicinal plants is restricted to the power of the insecticide on them (Calafiore and Barbieri, 2001; Raja et al., 2001; Cavalcante et al., 2006; Leite et al., 2006a; Morandi et al., 2006; Sharma and Gupta, 2007; Barbosa et al., 2009, 2011); intercalated plantations in orchards as a pest repellant plant (Kong et al., 2004) or as attractive to predators and parasitoids (Matioli et al., 1998; Kong et al., 2005; Leite et al., 2005b).

This way, the present work aimed to study the distribution of arthropods (herbivores, natural enemies, pollinators and protocooperators) throughout the canopy and the leaf surface in several medicinal plants, under organic cultivation, in Montes Claros, Minas Gerais State, Brazil.

## MATERIALS AND METHODS

The work was conducted in the Institute of Agricultural Sciences of the Federal University of Minas Gerais, Montes Claros, Minas Gerais State, Brazil (latitude - 16°30'25"S, longitude - 43°57'00"W, altitude - 650 m), from February of 2001 to December 2002. The statistical design was randomized with 10 repetitions (10 plants). Medicinal plants studied (Table 1) were grown under organic system, not using pesticides. Fertilization was performed using organic compost (bovine manure and silage rest). Cultural practices and the spacing used were recommended for each species (Corrêa et al., 1991). The plants were irrigated when necessary, by using the system of micro-aspersion with laser perforated hose.

The beds of each plant species contained 10 plants, all being assessed from 30 days old. Replanting varied according to the cycle of each medicinal plant, that is, the number of beds evaluated during the experiment period varied from species to species (Table 1), always being planted in different beds from the previous. Evaluations on herbivores, natural enemies, protocooperators and pollinators arthropods were performed by direct counting in biweekly intervals, being analyzed the abaxial and adaxial surfaces of three leaves per plant, one in each part of the canopy (apical, median, and basal ) plants in each plot. Arthropods were collected and stored in bottles with alcohol 70% for subsequent identification by taxonomists.

The data were transformed into root of X + 0.5 to meet the tests of Liliefors (normal distribution) and Cochran and Bartellet (homogeneity of variances), subjected to analysis of variance and, subsequently, submitted to the average test of Tukey and correlation of Pearson, all at 5% significance level.

## RESULTS

We observed a higher number of herbivorous insects in the apical leaves of the medicinal plants such as *Aphis gossypii* Glover (Hemiptera: Aphididae) in *Taraxacum officinale* (F = 28.412, P = 0.00000), *Foeniculum vulgare* (F = 21.809, P = 0.00000), *Artemisia absinthium* (F = 10.740, P = 0.00000), and *Mentha arvensis* (F = 4.879, P = 0.00794); *Empoasca* sp. (Hemiptera: Cicadellidae) in *Mentha x villosa* (F = 6.608, P = 0.00135) and *Origanum vulgare* (F = 5.560, P = 0.00416); thrips complex from the genus *Frankliniella* (Thysanoptera: Thripidae) [90.38% *Frankliniella schultzei* (Trybom) (46♀ and 1♂); 5.77% *Frankliniella oxyura* Bagnall (2♀ and 1♂); 1.92% *Frankliniella brevicaulis* Hood (1♀) and 1.92% *Frankliniella insularis* (Franklin) (1♀)] in *Calendula officinalis* (F = 14.087, P = 0.00025); *Lagria villosa* Fabr. (Coleoptera: Lagriidae) in *A. absinthium* (F = 5.005, P = 0.00687), *Achillea millefolium* (F = 5.298, P = 0.00530), and *Plantago major* (F = 6.902, P = 0.00107); *Leptoglossus* sp. (Hemiptera: Coreidae) in *Ocimum gratissimum* (F = 4.509, P = 0.01118) and *C. officinalis* (F = 6.123, P = 0.00251); *Sistena* sp. (Coleoptera: Chrysomelidae) in *C. officinalis* (F = 3.263, P = 0.03886) and *P. major* (F = 6.169, P = 0.00221); *Trigona spinipes* Fabr. (Hymenoptera: Apidae) in *Ocimum basilicum* (F = 10.786, P = 0.00000) and *Passiflora* sp.1 (F = 13.025, P = 0.00000); and *Uroleucon ambrosiae* (Thomas) f. *lizerianum* (E.E.Blanchard) (Hemiptera: Aphididae) in *C. officinalis* (F = 25.148, P = 0.00025) (Table 2). While in *Symphytum officinale*, *Empoasca* sp. (F = 4.899, P = 0.00765) preferred to attack the middle part of the canopy and *Liriomyza* sp. (F = 7.000, P = 0.00781) in *Cotyledon orbiculata* (Table 2).

It was noted the higher presence herbivorous insects on the abaxial face of leaves of the medicinal plant such as *A. gossypii* in *T. officinale* (F = 33.863, P = 0.00000), *F. vulgare* (F = 20.542, P = 0.00000), and *A. absinthium* (F = 5.135, P = 0.02387); *Empoasca* sp. in *M. x villosa* (F = 16.703, P = 0.00038), *O. gratissimum* (F = 4.146, P = 0.04209), *Ocimum selloi* (F = 6.083, P = 0.01381), *Solidago chilensis* (F = 4.048, P = 0.04472), *S. officinale* (F = 9.718, P = 0.00191), and *Thymus vulgaris* (F = 5.474, P = 0.01939); *Frankliniella* sp. (F = 12.115, P = 0.00057), *U. ambrosiae* f. *lizerianum* (F = 14.998, P = 0.00016), and *Leptoglossus* sp. (F = 6.128, P = 0.01349) in *C. officinalis*; *Liriomyza* sp. (F = 7.000, P = 0.01919) in *C. orbiculata*; *Coccus* sp. (Hemiptera: Coccidae) in *F. vulgare* (F = 7.419, P = 0.00666); *Deois flavopicta* (Stal) and *Zulia entreriana* (Berg) (Hemiptera: Cercopidae) in *Cymbopogon citratus* (F = 4.020, P = 0.04532), *Diabrotica speciosa* Germ. (Coleoptera: Chrysomelidae) in *S. officinale* (F = 5.989, P = 0.01466) and *F. vulgare* (F = 4.061, P = 0.04440); *L. villosa* in *S. officinale* (F = 4.028, P = 0.04518) and *F. vulgare* (F = 12.935, P = 0.00033); *Sistena* sp. (Coleoptera: Chrysomelidae) in *C. officinalis* (F = 7.547, P = 0.00615), *M. x villosa* (F = 8.437, P = 0.00406), and *S. officinale* (F = 9.263, P = 0.00244); *T. spinipes* in *O. basilicum* (F = 8.935, P = 0.00293); and *Xyleus* sp. (Orthoptera: Acrididae) in

**Table 1.** List of medicinal plants studied (number of crops).

| Family | Scientific name |
|---|---|
| Acanthaceae | *Altemanthaera dentata* L. (3), *Justicia pectoralis* var. *stenophylla* Leon. (1) |
| Alismataceae | *Echinodorus grandiflorus* Mitch. (2) |
| Amaranthaceae | *Pfaffia glomerata* (Spreng) Pedersen (2) |
| Asteraceae | *Anthemis cotula* L. (2) |
| Bignoniaceae | *Arrabidaea chica* Humb. e Bonpl. (2) |
| Boraginaceae | *Symphytum officinale* L. (2), *Cordia verbenacea* DC. (2) |
| Celastraceae | *Maytenus ilicifolia* Reissek (2) |
| Chenopodiaceae | *Chenopodium ambrosioides* L. (2) |
| Compositae | *Solidago chilensis* Meyen (1), *Tanacetum parthenium* L. (2), *Calendula officinalis* L. (3), *Vernonia condensata* Baker (2), *Chamomilla recutita* (L.) Rauschert (1), *Baccharis trimera* (Less.) DC. (2), *Tanacetum vulgare* L. (2), *Taraxacum officinale* Weber (5), *Eclipta alba* (L.) Hassk. (2), *Mikania glomerata* Spreng. (2), *Acmella oleracea* (L.) R.K.Jansen (2), *Artemisia absinthium* L. (2), *Achillea millefolium* L. (2) |
| Convolvulaceae | *Operculina macrocarpa* (L.) (1) |
| Crassulaceae | *Bryophyllum pinnatum* (Lam.) Oken (2), *Cotyledon orbiculata* L. (2) |
| Cucurbitaceae | *Luffa operculata* (L.) Cogn. (2), *Sicana odorifera* Naud (1) |
| Euphorbiaceae | *Phyllanthus* sp. (4), *Jatropha multifida* L. (3) |
| Gramineae | *Cymbopogon citratus* (DC) Stapf. (2), *Cymbopogon nardus* (L.) Rendle (2) |
| Guttiferae | *Hypericum perforatum* L. (1) |
| Iridaceae | *Eleutherine bulbosa* (Mill.) Urb. (1) |
| Lamiaceae | *Rosmarinus officinalis* L. (2), *Ocimum basilicum* L. (2), *Ocimum* sp. 1 (2), *Ocimum gratissimum* L. (2), *Ocimum* sp. 2 (1), *Ocimum selloi* Benth. (2), *Ocimum* sp. 3 (2), *Plectranthus grandis* (Cramer) Willems (2), *Stachys byzantina* K. Koch (1), *Ocimum* sp. (3), *Melissa officinalis* L. (1), *Mentha x villosa* Huds (2), *Origanum vulgare* L. (2), *Mentha pulegium* L. (2), *Salvia officinalis* L. (2), *Plectranthus barbatus* Andrews (2), *Plectantus amboinicus* (Lour.) Spreng (2). |
| Labiatae | *Thymus vulgaris* L. (2), *Mentha arvensis* L. (2) |
| Leguminosae | *Vigna angularis* (Willd.) Ohwi e Ohashi (2) |
| Liliaceae | *Allium tuberosum* Roxb (2), *Aloe vera* (L.) Burm. f. (2), *Aloe arborescens* Mill. (2) |
| Malvaceae | *Malva sylvestris* L. *(2)* |
| Passifloraceae | *Passiflora* sp. 1 (2), *Passiflora* sp. 2 (1), *Passiflora* sp. 3 (2), *Passiflora* sp. 4 (2) |
| Piperaceae | *Pothomorphe umbellata* (L.) Miq. (2), *Piper angustifolium* Lam. (2) |
| Plantaginaceae | *Plantago major* L. (2) |
| Polypodiaceae | *Equisetum hiemale* L. (2) |
| Rutaceae | *Ruta graveolens* L. (2) |
| Scrophulariaceae | *Capraria biflora* L. (2) |
| Solanaceae | *Solanum cernucim* Vell. (1), *Lycopersicon pipinellifolium* Mill. (2) |
| Tropaeolaceae | *Tropaeolum majus* L. (1) |
| Umbelliferae | *Centella asiatica* L. (1), *Eryngium foetidium* L. (2), *Pimpinella anisum* L. (2), *Foeniculum vulgare* Mill. (2) |
| Verbenaceae | *Lippia gracilis* Schauer (2), Unidentified (2), *Lippia alba* (Mill.) (2), *Stachytarpheta cayennensis* (Rich.) Vahl (2) |
| Vitaceae | *Cissus sicyoides* L. (1) |
| Zingiberaceae | *Curcuma* sp. (3), *Costus spicatus* (Jacq.) Sw. (2), *Alpinia zerumbet* (Pers.) Burtt e Smith (2), *Zingiber officinale* Roscoe (1) |

**Table 2.** Mean number (± standard error)/leaf of herbivorous insect in different parts of the canopy of medicinal plants.

| Vegetable species | Canopy part | | |
|---|---|---|---|
| | Apical | Middle | Basal |
| | | ***Aphis gossypii* Glover (Hemiptera: Aphididae)** | |
| *Taraxacum officinale* | 1.86±0.36 A | 0.06±0.02 B | 0.20±0.18 B |
| *Foeniculum vulgare* | 7.47±1.81 A | 0.04±0.04 B | 0.00±0.00 B |
| *Artemisia absinthium* | 14.64±7.60 A | 0.51±0.18 B | 0.00±0.00 B |
| *Mentha arvensis* | 0.43±0.13 A | 0.16±0.08 AB | 0.05±0.03 B |
| | | ***Empoasca* sp. (Hemiptera: Cicadellidae)** | |
| *Symphytum officinale* | 0.02±0.01 AB | 0.04±0.01 A | 0.00±0.00 B |
| *Mentha x villosa* | 0.03±0.01 A | 0.01±0.00 B | 0.00±0.00 B |
| *Origanum vulgare* | 0.03±0.01 A | 0.00±0.00 B | 0.00±0.00B |
| | | ***Frankliniella* sp. (Thysanoptera: Thripidae)** | |
| *Calendula officinalis* | 0.18±0.05 A | 0.00±0.00 B | 0.00±0.00 B |
| | | ***Lagria villosa* Fabr. (Coleoptera: Lagriidae)** | |
| *Artemisia absinthium* | 0.11±0.05 A | 0.01±0.01 B | 0.00±0.00 B |
| *Achillea millefolium* | 0.03±0.01 A | 0.00±0.00 B | 0.00±0.00 B |
| *Plantago major* | 0.04±0.01 A | 0.00±0.00 B | 0.00±0.00 B |
| | | ***Leptoglossus* sp. (Hemiptera: Coreidae)** | |
| *Ocimum gratissimum* | 0.03±0.01 A | 0.00±0.00 B | 0.02±0.01 AB |
| *Calendula officinalis* | 0.02±0.01 A | 0.00±0.00 B | 0.00±0.00B |
| | | **Mines of *Liriomyza* sp. (Diptera: Agromyzidae)** | |
| *Cotyledon orbiculata* | 0.00±0.00 B | 0.50±0.22 A | 0.00±0.00 B |
| | | ***Sistena* sp. (Coleoptera: Chrysomelidae)** | |
| *Calendula officinalis* | 0.02±0.01 A | 0.00±0.00 B | 0.00±0.00 B |
| *Plantago major* | 0.03±0.01 A | 0.00±0.00 B | 0.00±0.00 B |
| | | ***Trigona spinipes* Fabr. (Hymenoptera: Apidae)** | |
| *Ocimum basilicum* | 0.18±0.05 A | 0.00±0.00 B | 0.01±0.01 B |
| *Passiflora* sp.1 | 0.22±0.04 A | 0.04±0.02 B | 0.02±0.01 B |
| | | ***Uroleucon ambrosiae* (Thomas) f. *lizerianum* (E. E. Blanchard) (Hemiptera: Aphididae)** | |
| *Calendula officinalis* | 1.74±0.33 A | 0.28±0.18 B | 0.09±0.08 B |

Means followed by same capital letter in the line do not differ among themselves by Tukey test at 5% significance level.

*S. officinale* (F = 8.210, P = 0.00431), *A. absinthium* (F = 4.029, P = 0.04520), and *Plectranthus barbatus* (F = 4.039, P = 0.04460) (Table 3). However, in *Acmella oleracea*, *Coccus* sp. (F = 4.049, P = 0.04481) preferentially attacked the upper face of the leaves (Table 3).

The aphids caused, when in higher densities, curling of leaves and, as also observed for the mealybugs, the appearance of sooty mold due to excretion of honeydew on medicinal plants. The attack of thrips resulted in chlorotic spots on leaves of *C. officinalis* and beetles in defoliation. It was not a perceived effect of the apparent attack of cicadellids and bedbugs on medicinal plants. In relation to natural enemies and protocooperators, we observed higher number of *Crematogaster* sp. (Hymenoptera: Formicidae) in the apical third of *M. x villosa* (F = 4.445, P = 0.01184) and middle third of *Ocimum* sp. (F = 7.333, P = 0.00103); there were more spiders [*Argiope* sp. and *Parawixia* spp. (Araneidae), *Cheiracanthium inclusum* (Hentz) (Miturgidae),

**Table 3.** Mean number (±standard error)/leaf surface of herbivorous insects on the leaf surface of medicinal plants.

| Vegetable species | Leaf surface | |
|---|---|---|
| | Abaxial | Adaxial |
| | ***Aphis gossypii* Glover (Hemiptera: Aphididae)** | |
| *Taraxacum officinale* | 1.37±0.27 A | 0.04±0.02 B |
| *Foeniculum vulgare* | 4.94±1.22 A | 0.07±0.07 B |
| *Artemisia absinthium* | 8.95±5.05 A | 1.14±0.48 B |
| | ***Coccus* sp. (Hemiptera: Coccidae)** | |
| *Foeniculum vulgare* | 1.54±0.60 A | 0.00±0.00 B |
| *Acmella oleracea* | 0.52±0.21 B | 2.77±0.94 A |
| | ***Deois flavopicta* (Stal) and *Zulia entreriana* (Berg) (Hemiptera: Cercopidae)** | |
| *Cymbopogon citratus* | 0.01±0.00 A | 0.00±0.00 B |
| | ***Diabrotica speciosa* Germ. (Coleoptera: Chrysomelidae)** | |
| *Symphytum officinale* | 0.05±0.02 A | 0.00±0.00 B |
| *Foeniculum vulgare* | 0.02±0.01 A | 0.00±0.00 B |
| | ***Empoasca* sp. (Hemiptera: Cicadellidae)** | |
| *Ocimum gratissimum* | 0.01±0.00 A | 0.00±0.00 B |
| *Ocimum selloi* | 0.01±0.00 A | 0.00±0.00 B |
| *Solidago chilensis* | 0.02±0.01 A | 0.00±0.00 B |
| *Symphytum officinale* | 0.04±0.01 A | 0.00±0.00 B |
| *Mentha x villosa* | 0.03±0.01 A | 0.00±0.00 B |
| *Thymus vulgaris* | 0.03±0.01 A | 0.00±0.00 B |
| | ***Frankliniella* sp. (Thysanoptera: Thripidae)** | |
| *Calendula officinalis* | 0.12±0.03 A | 0.00±0.00 B |
| | ***Lagria villosa* Fabr. (Coleoptera: Lagriidae)** | |
| *Symphytum officinale* | 0.01±0.00 A | 0.00±0.00 B |
| *Foeniculum vulgare* | 0.08±0.02 A | 0.00±0.00 B |
| | ***Leptoglossus* sp. (Hemiptera: Coreidae)** | |
| *Calendula officinalis* | 0.01±0.00 A | 0.00±0.00 B |
| | **Mines of *Liriomyza* sp. (Diptera: Agromyzidae)** | |
| *Cotyledon orbiculata* | 0.33±0.16 A | 0.00±0.00 B |
| | ***Sistena* sp. (Coleoptera: Chrysomelidae)** | |
| *Calendula officinalis* | 0.02±0.01 A | 0.00±0.00 B |
| *Mentha x villosa* | 0.01±0.00 A | 0.00±0.00 B |
| *Symphytum officinale* | 0.03±0.01 A | 0.00±0.00 B |
| | ***Trigona spinipes* Fabr. (Hymenoptera: Apidae)** | |
| *Ocimum basilicum* | 0.12±0.03 A | 0.01±0.00 B |
| | ***Uroleucon ambrosiae* f. *lizerianum* (Blanchard) (Hemiptera: Aphididae)** | |
| *Calendula officinalis* | 1.14±0.23 A | 0.27±0.10 B |

**Table 3.** Contd.

| | ***Xyleus* sp. (Orthoptera: Acrididae)** | |
|---|---|---|
| *Symphytum officinale* | 0.03±0.01 A | 0.00±0.00 B |
| *Artemisia absinthium* | 0.01±0.00 A | 0.00±0.00 B |
| *Plectranthus barbatus* | 0.01±0.00 A | 0.00±0.00 B |

Means followed by same capital letter in the line do not differ among themselves by Tukey test at 5% significance.

**Table 4.** Mean number (± standard error)/leaf of ants and natural enemies in different parts of the canopy of medicinal plants.

| Vegetable species | Canopy part | | |
|---|---|---|---|
| | Apical | Middle | Basal |
| | ***Crematogaster* sp. (Hymenoptera: Formicidae)** | | |
| *Ocimum sp.* | 0.00±0.00 B | 0.79±0.29 A | 0.00±0.00 B |
| *Mentha x villosa* | 0.01±0.00 A | 0.00±0.00 B | 0.00±0.00 B |
| | **Spiders** | | |
| *Artemisia absinthium* | 0.00±0.00 B | 0.01±0.00 A | 0.00±0.00 B |
| *Mentha x villosa* | 0.01±0.00 AB | 0.02±0.01 A | 0.00±0.00 B |
| *Achillea millefolium* | 0.02±0.01 A | 0.00±0.00 B | 0.00±0.00 B |
| | ***Cycloneda sanguinea* L. (Coleoptera: Coccinellidae)** | | |
| *Artemisia absinthium* | 0.18±0.06 A | 0.01±0.01 B | 0.00±0.00 B |
| *Taraxacum officinale* | 0.04±0.01 A | 0.00±0.00 B | 0.00±0.00 B |
| | ***Eriopsis conexa* Germar (Coleoptera: Coccinellidae)** | | |
| *Foeniculum vulgare* | 0.32±0.12 A | 0.07±0.03 B | 0.01±0.00 B |

Means followed by same capital letter in the line do not differ among themselves by Tukey test at 5% significance.

*Misumenops* sp. (Thomisidae), *Oxyopes* sp. and *Peucetia rubrolineata* (Hentz) (Oxyopidae), *Paracleocnemis* sp. (Philodromidae), Salticidae and Theridiidae] in the apical third of *A. millefolium* (F = 6.132, P = 0.00241), and in the middle third of *M. x villosa* (F = 6.251, P = 0.00194) and *A. absinthium* (F = 4.044, P = 0.01784), being these associated with beetles (r = 0.14, p = 0.0001); *Cycloneda sanguinea* L. (Coleoptera: Coccinelidae) in the apical leaves of *A. absinthium* (F = 9.088, P = 0.00008) and *T. officinale* (F = 5.885, P = 0.00254); and *Eriopsis conexa* Germar (Coleoptera: Coccinellidae) in the apical leaves of *F. vulgare* (F = 6.085, P = 0.00243) (Table 4).

Ants *Crematogaster* sp. were most noticeable on the abaxial face of the leaves of *O. selloi* (F = 5.044, P = 0.02494), *Rosmarinus officinalis* (F = 9.419, P = 0.00224), *Costus spicatus* (F = 5.298, P = 0.02169), *T. officinale* (F = 4.752, P = 0.02936) and *A. oleracea* (F = 6.224, P = 0.01296), and in the adaxial face of *A. millefolium* (F = 6.132, P = 0.01350) and *Ocimum* sp. (F = 7.333, P = 0.00784); spiders on the abaxial face of leaves of *A. millefolium* (F = 5.610, P = 0.01811) and *M. x villosa* (F = 6.508, P = 0.01115); and the ladybugs *C. sanguinea* and *E. conexa* were observed preying on aphids (r = 0.35, p = 0.0017) in the abaxial face of leaves of *T. officinale* (F = 7.116, P = 0.00766) and *F. vulgare* (F = 8.138, P = 0.0049), respectively (Table 5). There was no difference in the distribution of other arthropods in the canopy (P > 0.05) and the leaf surface (P > 0.05) in other medicinal plants in this study, not making distinction between them, such as *Coccus* sp. in *Alpinia zerumbet* and *Phyllanthus* sp.; *Solenopsis saevissima* (F. Smith) (Hymenoptera: Formicidae) in *A. zerumbet* and *Solanum cernucim*; *Zelus* sp. (Hemiptera: Reduviidae), *Xyonysius* sp. (Hemiptera: Lygaeidae), *Prepops* sp. (Hemiptera: Miridae), *Proba vittiscutis* Stal. (Hemiptera: Miridae), and *Harmostes* sp. (Hemiptera: Rhopalidae) in *Pfaffia glomerata*; *Aphis spiraecola* Patch (Hemiptera: Aphididae) in *C. officinallis* and *Baccharis trimera*; *Aetalion reticulatum* (L.) (Hemiptera: Aetalionidae) in *Vernonia condensata*; *Xestocephalus* sp. (Hemiptera: Cicadellidae) and Alydinae (Hemiptera: Alydidae) in *C. officinalis*; *Diactor bilineatus* (Fabr.) (Hemiptera: Coreidae) and *Dione juno juno* (Cramer) (Lepidoptera:

**Table 5.** Mean number (±standard error)/leaf surface of ants and natural enemies on the leaf surface of medicinal plants.

| Vegetable species | Leaf surface | |
|---|---|---|
| | Abaxial | Adaxial |
| | ***Crematogaster* sp. (Hymenoptera: Formicidae)** | |
| *Rosmarinus officinalis* | 0.10±0.04 A | 0.00±0.00 B |
| *Ocimum selloi* | 0.01±0.00 A | 0.00±0.00 B |
| *Costus spicatus* | 0.02±0.01 A | 0.00±0.00 B |
| *Taraxacum officinale* | 0.01±0.00 A | 0.00±0.00 B |
| *Acmella oleracea* | 0.03±0.01 A | 0.00±0.00 B |
| *Ocimum* sp. | 0.00±0.00 B | 0.53±0.20 A |
| *Achillea millefolium* | 0.00±0.00 B | 0.09±0.03 A |
| | **Spiders** | |
| *Mentha x villosa* | 0.02±0.00 A | 0.00±0.00 B |
| *Achillea millefolium* | 0.01±0.00 A | 0.00±0.00 B |
| | ***Cycloneda sanguinea* L. (Coleoptera: Coccinellidae)** | |
| *Taraxacum officinale* | 0.03±0.01 A | 0.00±0.00 B |
| | ***Eriopsis conexa* Germar (Coleoptera: Coccinellidae)** | |
| *Foeniculum vulgare* | 0.23±0.08 A | 0.03±0.02 B |

Means followed by same capital letter in the line do not differ among themselves by Tukey test at 5% significance.

Nymphalidae) in *Passiflora*; *Atta sexdens* Forel (Hymenoptera: Formicidae) in *Hypericum perforatum*; *Euphoria* sp. (Coleoptera: Cetoniidae) and Chalcophanini (Coleoptera: Chrysomelidae: Eumolpinae) in *Cordia verbenacea*; *Malthinus* sp. (Coleoptera: Cantaridae) in *S. chilensis*; *Apis mellifera* (L.) (Hymenoptera: Apidae) in *Plectranthus grandis*, *Ociminum* sp. and *Passiflora*, and *Centris* sp (Hymenoptera: Apidae) in the last plant.

## DISCUSSION

It could be observed that herbivorous insects such as aphids, cicadellids, bugs, thrips complex, beetles and mealybugs, in general, more on the abaxial face of apical leaves of several medicinal plants. Silva et al. (2009) observed a higher attack of *Insignorthezia insignis* (Browne) (Hemiptera: Ortheziidae), *Phenacoccus* sp. (Hemiptera: Pseudococcidae) and *Frankliniella* sp. in the apical leaves of *Lippia sidoides* Cham. (Verbenaceae), the same being observed for *A. gossypii* in *Pfaffia glomerata* Spreng. (Amaranthaceae) and *L. sidoides* (Leite et al., 2007, 2008). Major attack on the abaxial face was also noted for *I. Insignis*, *Phenacoccus* sp. and *Frankliniella* sp. in *Lippia gracilis* Schauer (Verbenaceae) (Silva et al., 2009), and for *A. Gossypii* in *P. glomerata*, and *U. ambrosiae* f. *Lizerianum* and *A. spiraecola* (Hemiptera: Aphididae) Patch in *C. officinalis* (Leite et al., 2005a, 2008). However, Leite et al. (2007) observed higher attack of *A. gossypii* on the adaxial surface of *Ageratum conyzoides* L. (Asteraceae) leaves.

The insects prefer tender plant tissues, usually located in the apical third, followed by the median because of better nutritional quality, especially in the case of chewing, and/or bigger facility to access the phloem (that is, sucking insects) (Miranda et al., 1998; Silva et al., 1998; Leite et al., 1998). Besides that, insects, especially suckers, are often located on the underside of the leaves, for having thinner surface and more prominent ribbing, favoring the feeding, and also for serving as protection against weather and natural enemies (Leite et al., 1998). A greater number of mines of leafminer-fly in median leaves were noticed. Initially, this insect oviposition occurs in the apical third; however, with plant growth and the emission of new leaves, the attacked parts started to compose the middle third of the plants (Oliveira, 1999; Leite et al., 2004). We noted the natural enemies (that is, ladybugs) and protocooperators (ants), in general, in the same places of the herbivorous insects. Leite et al. (2008) reported a greater number of ants on the abaxial face of the apical part of *P. glomerata* plant and negative effect of spiders Araneidae, Miturgidae, *Misumenops* sp. (Thomisidae), Tetragnathidae, and Theridiidae on the population of defoliator beetles and a population increase of these predators with the growth of cicadellids on *P. glomerata*. In *P. glomerata*, these same families and the

genus of spiders were associated with *Empoasca* sp., *D. speciosa* and *T. spinipes* (Leite et al., 2005b). The ladybugs (Coccinellidae) were observed preying on aphids in some medicinal plants. Similar results were reported for *Scymnus* sp. (Coleoptera: Coleoptera) with whitefly and aphids in *L. gracilis* (Silva et al., 2009), in *C. officinalis* (Leite et al., 2005a), and a negative effect *C. sanguinea* on population growth of *A. Gossypii* on *P. glomerata* (Leite et al., 2008).

Ladybugs and spiders are important predators and should therefore be kept in the fields (Miranda et al., 1998; Gallo et al., 2002), mainly in fields of medicinal plants, in which is not recommended the use of pesticides. Ants, although no significant correlation was detected, are usually protocooperators of aphids, protecting them against natural enemies (Picanço et al., 1997), being necessary to control them, so that we can increase the natural biological control. In other works with medicinal plants, ants were also associated with population increase of sucking insects (Leite et al., 2005a, b; Silva et al., 2009). There was no difference in the distribution of the large part of the herbivorous insects in the canopy and the leaf surface of the several medicinal plants in this study, probably due to low density of the arthropods on the plants (Leite et al., 2006b). This fact might be due to chemicals present in their leaves (Simões et al., 2000) and / or because the plants were grown under an organic system, which provides the nutrients more slowly reducing the pest attack (Chaboussou, 1987; Marschner, 1995) and / or polyculture (Altieri et al., 2003). Out of the herbivores observed, aphids, mealybugs, thrips and beetles stand out, for their higher densities and economic importance as pests in various crops, such as Brassicaceae, Solanaceae, Liliaceae, Cucurbitaceae, among others (Gallo et al., 2002).

The Brazilian Pharmacopoeia (Brandão et al., 1998) admits at most 5% strange matter (stems, leaves, insects) in the trade of medicinal plants and herbal medicines. However, a study evaluated the quality of *Matricaria recutita* L. (Asteraceae) marketed, it was found that the 27 samples analyzed, all showed contamination by organic matter, while 63% of the samples sold in drugstores contained insects, resulting in lost quality of the product (Ming, 1994; Brandão et al., 1998). Therefore, there is the need to maintain low population density of herbivores insects, because the economic harm they can cause is more qualitative than quantitative. For this, use of crop rotation, policultive, organic fertilizer and mulch are practices that should be adopted to reduce the pest population because they reduce the initial focus of attack, difficult the location of crops by pests and increases the natural biological control (Amador and Hilje, 1993; Altieri et al., 2003). In the case of the need of chemical intervention, a possibility is the use of natural compounds by plants, easily degraded and of little impact on ecosystems (Gallo et al., 2002), directing the spray in the apical leaves of medicinal plants, in such a manner that could also reach the abaxial face of the leaves, because these are areas where they concentrate most of the herbivores found in medicinal plants.

## Conclusions

1. Overall, we found a greater number of insects on the abaxial face of apical leaves of medicinal plants.
2. Out of the herbivores observed, aphids, mealybugs, thrips and beetles stand out by their abundance and damage.

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