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Original Article

Insecticidal activity of essential oils on *Spodoptera frugiperda* and selectivity to *Euborellia annulipes*

Atividade inseticida de óleos essenciais sobre *Spodoptera frugiperda* e seletividade para *Euborellia annulipes*

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Abstract

Fall armyworm (*Spodoptera frugiperda*) is the main species that causes damage to the maize crop in Brazil. In the perspective of studying alternatives of control of this pest that preserve the natural enemies, the aim of this research was to evaluate the insecticidal efficiency of the essential oils of *Vanillosmopsis arborea* and *Lippia microphylla* on *S. frugiperda* and verify the selectivity to the predator *Euborellia annulipes*. The bioassays were carried out in the Agricultural Entomology Laboratory of the Federal University of Paraiba, using insects, from 3rd instar of *S. frugiperda* and *E. annulipes*, originating from mass rearing in the laboratory itself. Dilutions of the oils were performed in Tween® 80 at concentrations of 0, 100, 150 and 200 mg mL^{-1}. 1.0 µL from each dilution was applied to the prothoracic region of the insects. The *S. frugiperda* mortality was verified by topical contact of *V. arborea* oil with LC_{10} = 74.3 mg mL^{-1} and LC_{50} = 172.86 mg mL^{-1}, for *L. microphyla*, LC_{10} = 51.26 mg mL^{-1} and LC_{50} = 104.52 mg mL^{-1}. The observed lethal concentrations for *E. annulipes* were *V. arborea* LC_{10} = 71.3 mg mL^{-1} and LC_{50} = 160.2 mg mL^{-1}. While *L. microphyla*, were LC_{10} = 50.3 mg mL^{-1} and LC_{50} = 134.67 mg mL^{-1}. The essential oils of *V. arborea* and *L. microphylla* are efficient in the control of *S. frugiperda*, but are not selective to the predator *E. Annulipes*.

Keywords: fall armyworm, ring-legged earwing, insecticide botanical, α-bisabolol, 1,8-cineole.

Resumo

A lagarta-do-cartucho (*Spodoptera frugiperda*) é a principal espécie que causa danos à cultura do milho no Brasil. Na perspectiva de estudar alternativas de controle desta praga que preservem os inimigos naturais, o objetivo desta pesquisa foi avaliar a eficiência inseticida dos óleos essenciais de *Vanillosmopsis arborea* e *Lippia microphylla* sobre *S. frugiperda* e verificar a seletividade ao predador *Euborellia annulipes*. Os bioensaios foram realizados no Laboratório de Entomologia Agropecuária da Universidade Federal da Paraíba, utilizando insetos, de 3º instar de *S. frugiperda* e *E. annulipes*, oriundos de criação massal no próprio laboratório. As diluições dos óleos foram realizadas em Tween® 80 nas concentrações de 0, 100, 150 e 200 mg mL^{-1}. 1,0 µL de cada diluição foi aplicado na região protorácica dos insetos. A mortalidade de *S. frugiperda* foi verificada pelo contato tópico do óleo de *V. arborea* com LC10 = 74,3 mg mL^{-1} e LC50 = 172,86 mg mL^{-1}, para *L. microphyla*, LC10 = 51,26 mg mL^{-1} e LC50 = 104,52 mg mL^{-1}. As concentrações letais observadas para *E. annulipes* foram *V. arborea* LC10 = 71,3 mg mL^{-1} e LC50 = 160,2 mg mL^{-1}. Enquanto *L. microphyla*, foram LC10 = 50,3 mg mL^{-1} e LC50 = 134,67 mg mL^{-1}. Os óleos essenciais de *V. arborea* e *L. microphylla* são eficientes no controle de *S. frugiperda*, mas não são seletivos ao predador *E. Annulipes*.

Palavras-chaves: lagarta-do-cartucho, tesourinha, inseticida botânico, α-bisabolol, 1,8-cineol.

1. Introduction

Fall armyworm (*Spodoptera frugiperda* J. E. Smith - Lepidoptera: Noctuidae) is the main species causing damage to maize crop in Brazil (Nagoshi et al., 2007). This pest is characterized by the reduction of productivity and the quality of the final product, as well as the difficulty of controlling the emergence of populations resistant to chemical insecticides (Nebo et al., 2010; Carvalho et al., 2013).

Due to the loss of efficiency of a large number of chemical insecticides, new alternatives to control this pest must be studied, such as the use of biological control and the use of botanical insecticides. Among the natural enemies of *S. frugiperda*, it has in the order Dermaptera efficient insects in the control of this pest. In studies with *Euborellia annulipes* Lucas (Dermaptera: Anisolabididae), it was observed that it represents an important agent

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of biological control. This species has a high predatory potential on eggs of fall armyworm *S. frugiperda* (Silva et al., 2009).

Studies on botanical insecticides are essential because they have been instrumental in the discovery and development of synthetic chemicals. In examining the chemical constitution of essential oils, a solid basis is obtained for the construction of a chemical molecule that may be more specific to a pest or pathogen, while at the same time having a more rapid degradation in the environment (Senthil-Nathan, 2013; Vasantha-Srinivasan et al., 2016).

Some essential oils have already been studied for the control of *S. frugiperda*. Niculau et al. (2013) evaluated the oils of the plants *Pelargonium graveolens* L'Hér., *Lippia alba* Mill and the isolated compounds geraniol, linalool, carvone and citral, observing high toxicity on this pest. Lima et al. (2009a), also doing studies with vegetable oils, observed the potential insecticide of long chilli pepper (*Piper hispidinervum*) on third instar larvae of *S. frugiperda*. The essential oil of candeeiro (*Vanillosmopsis arborea*) has already had its insecticidal action studied on insect vector of diseases, *Aedes aegypti* and had proven efficiency by Silva et al. (2017).

The integrated management programs always aim to preserve natural enemies and a tool that can aid in the preservation of beneficial insects is the use of selective insecticides. When comparing the toxic effects of insecticides among insect species, it can be represented by the concentration curve, if the products are selective to the natural enemies and efficient against insect pests (Bacci et al., 2012).

Therefore, the aim of this study was to evaluate the insecticidal efficiency of the essential oils of *Vanillosmopsis arborea* and *Lippia microphylla* on the fall armyworm (*S. frugiperda*) and selectivity to the predator *E. annulipes*.

2. Material and Methods

2.1. Search location

The research was carried out at the Agricultural Entomology Laboratory of the Universidade Federal da Paraiba (LEN/UFPB), Areia, Paraíba. In order to perform the bioassays, it was used insects of 3rd instar larval of *S. frugiperda* and *E. annulipes* from pre-established breeding on artificial diet in the laboratory.

2.2. Breeding of ring-legged earwing

The insects came from pre-established breeding in the LEN/UFPB. They were kept in rectangular and transparent plastic boxes, 22.5 x 15.0 x 6.0 cm. To avoid insect escape, each breeding box was kept sealed with a dark cap, having a 2.5 cm diameter bore, sealed with voile fabric, to provide an environment free of light and oxygenated, ideal for the development and reproduction of the insect. The bottoms of the breeding boxes were covered by layers of hygienic absorbent paper, approximately 2.0 cm high. The paper layer was moistened daily with distilled water to maintain high humidity inside the boxes and provide protection for the ring-legged earwing. Weekly, the paper covering the basal part of the boxes was changed and the females with their respective postures were transferred to a Petri dish of 9.0 cm in diameter x 1.0 cm in height, with feeding on absorbent paper moistened with distilled water. The adults and the nymphs of *E. annulipes* were fed with artificial diet which composition and quantity were: milk powder (130 g), brewer's yeast (220 g), wheat bran (260 g), initial feed for broiler chicken (350 g) and Nipagin (40 g).

2.3. Breeding of fall armyworm

The fall armyworm were individually maintained in glass tubes of bottom flattened of 2.5 cm diameter x 8.5 cm height, previously sterilized, containing artificial diet. The openings of the tubes were buffered with cotton and kept in an air-conditioned room type BOD, until the pupal stage. The contents of the artificial diet was filled up to 1/4 of the height of the tubes. After sexing the pupae, 10 pairs of *S. frugiperda* were placed in PVC cages (polyvinyl chloride) 20 cm in diameter by 20 cm in height and internally coated with sulphite paper, with the upper end covered by voile fabric and lower by plastic material. Adults were fed a 10% water and honey solution.

2.4. Essential oils extraction

The essential oils were extracted from leaves of alecrim de tabuleiro (*Lippia microphylla* Cham.) and stem of candeeiro (*Vanillosmopsis arborea* Baker), harvested respectively, in the towns of Lavras da Mangabeira and Crato, Ceará. The storage of the plants in the field was done in dark colored bags and then taken to the Product Technology Laboratory (LTP) of the Center of Agrarian Sciences and Biodiversity of the Universidade Federal do Cariri (CCAB/UFCA). The extraction of the essential oils was done by the hydrodistillation method in Clevenger type apparatus, according to methodology described by Alencar et al. (1984). It was weighed 300 g of each material and placed submerged in 2 mL of distilled water on a round bottomed flask with capacity for 5 mL, establishing an extraction period of 120 minutes. After the extraction period, the essential oil was removed from the apparatus with the aid of a Pasteur pipette and stored in eppendorf covered with aluminum foil and stored in a refrigerator.

2.5. Identification and quantification of the essential oils constituents

Identification and quantification of the essential oils constituents of *L. microphylla* and *V. arborea* was done by gas chromatography coupled to mass spectrometry (GC/MS)/QP2010 Ultra, brand Shimadzu, under the following conditions: RTX-5MS capillary column (5% Diphenyl/95% dimethyl polysiloxane), size 30 m (length)/0.25 mm internal diameter/and film thickness 0.25 µm df, injection temperature 250 °C, detector 200 °C. Realized by the Institute of Research in Drugs and Medicines (IPeFarM) of the Universidade Federal da Paraíba.

2.6. Test by topical contact in S. frugiperda and selectivity to E. annulipes

The test by topical contact was performed on 3rd instar larvae of fall armyworm. The essential oils of *V. arborea* and *L. microphylla* were diluted in Tween® 80, obtaining the concentrations of 0, 50, 100, 150 and 200 mg mL^{-1}. For each concentration ten replicates were used with 1 fall armyworm. The bioassay consisted of the application of 1.0 µL of each dilution by means of a micropipette in the prothoracic region of the insect. The concentration of 0 mg mL^{-1} was the negative control, consisting only of water + Tween® 80. After application of the treatments, the insects were placed in Petri dishes with feed and kept in a controlled environment, with temperature of 25 ± 1 ºC, relative humidity 70 ± 10% and photoperiod of 12 hours.

The same procedure was performed with 3rd instar nymphs of the predator *E. annulipes*, which were anesthetized in a refrigerator at 4 °C for two minutes before applying the treatments. For each concentration of the oil, five replicates, containing five nymphs, were used. The acute toxicity of the essential oils was evaluated at the intervals of 24, 48 and 72 hours after application of the products, counting the number of dead fall armyworm and nymphs.

2.7. Statistical analysis

To determine the lethal concentrations (LC_{10} and LC_{50}) of the *V. arborea* and *L. microphylla* oils, a binomial logistic regression analysis was performed using the R (R Core Team, 2019) software, with confidence interval at the level of 0.01 of significance. The mortality efficiency was corrected by formula of Abbott (1925): CM(%) = ((Nc-Nt)/Nc)x100, where, CM = corrected mortality, Nc = number of individuals alive in the control treatment and Nt = number of individuals alive in the treatments.

3. Results

3.1. Characterization of the essential oils of V. arborea and L. microphylla

13 compounds was identified in the essential oil of candeeiro (*V. arborea*): octacosane (0.07%), α-terpineol (0.07%), ether and 3-butenyl propyl (0.09%), 2-hexanone and 3,3-dimethyl (0.09%), β-camigrene (0.15%), caryophyllene (0.21%), spathulenol (0.3%), 1,8-cineole (0.45%), elemycin (0.47%), vanilosmin (0.51%), α-bisabolol oxide (1.03%), methyl eugenol (2.39%) and the major compound α-bisabolol (94.17%).

31 compounds was verified on essential oil of alecrim de tabuleiro (*L. microphylla*): α-thujene (0.26%), α-pinene (3.75%), oxalic acid and hexyl propyl ester (0.06%), 2-hexanone and 3,3-dimethyl (0.05%), sabinene (3.74%), β-pinene (1.19%), myracene (1.02%), α-phellandrene (0.13%), δ-3-carene (0.35%), α-terpinene (0.16%), p-cymene (1.05%), limonene (1.00%), Z-ocimene (0.11%), γ-terpinene (0.80%), cis-β-terpineol (0.62%), terpinolene (0.19%), isopinocampheol (0.13%), 8-hidroxilinalol (0.07%), D-terpineol (0.55%), 4-terpineol (1.19%), α-terpineol (8.08%), copaene (0.17%), isocarofilene (0.69%), δ-cadinene (0.10%), spathulenol (0.13%), caryophyllene oxide (0.19%) and the major compound 1,8-cineole (73.29%).

3.2. Mortality of S. frugiperda treated with essential oils of V. arborea and L. microphylla

For the mortality of 3rd instar of *S. frugiperda*, sources of variation treatments (*V. arborea* and *L. microphylla*) (P = 0.98), treatments *versus* concentrations (P = 0.29), evaluation period (P = 1.00), evaluation period *versus* treatments (P = 1.00), evaluation period *versus* concentrations (P = 1.00), and treatments *versus* concentrations *versus* the evaluation period (P = 1.00), were not statistically significant by the F test. However, the concentration factor (P < 0.0001) was significant at 1% probability by the same test.

The mortality probability curve of 3rd instar of *S. frugiperda* can be observed when submitted to the topical action of the essential oils of *V. arborea* and *L. microphylla* (Figure 1). The two evaluated oils were efficient, causing a high mortality rate in the fall armyworm. It is also noted the direct relation between the increase in the concentration of essential oils and the higher probability of insect mortality.

The lethal concentrations of the essential oils of *V. arborea* and *L. microphyla* capable of killing 10% (LC_{10}) and 50% (LC_{50}) of the *S. frugiperda* were evaluated (Table 1).

The essential oil of *V. arborea* presented LC_{10} of 74.30 mg mL^{-1} and LC_{50} of 172.86 mg mL^{-1}. While *L. microphyla* oil presented LC_{10} of 51.26 mg mL^{-1} and LC_{50} of 104.52 mg mL^{-1}, that is, a lower concentration of *L. microphyla* was

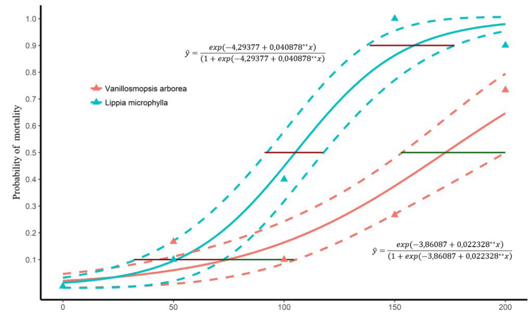

Figure 1. Probability of mortality of *S. frugiperda* submitted to the essential oils of *V. arborea* and *L. microphyla*.

Table 1. Minimum concentrations (LC_{10}) and average (LC_{50}) of *V. arborea* and *L. microphyla* essential oils on 3rd instar of *S. frugiperda*.

Species	LC_{10} (CI 5%) mg mL^{-1}	LC_{50} (CI 5%) mg mL^{-1}
Vanillosmopsis arborea	74.30	172.86
	43.30 - 104.50	152.80 - 200.00
Lippia microphyla	51.26	104.52
	32.16 - 72.36	91.15 - 117.58

required to kill 10 and 50% of the fall armyworm, when compared to the oil of *V. arborea*.

The morphological characterization of *S. frugiperda* was carried out using the magnifying glass Discovery (V12 SteREO ZEISS) after verifying the mortality of this pest by the essential oils of *L. microphylla* and *V. arborea* (Figure 2).

3.3. Selectivity of the essential oils of V. arborea and L. microphylla the ring-legged earwing (E. annulipes)

For the mortality of 3rd instar nymphs of the predator *E. annulipes*, the sources of variation treatments (*V. arborea* and *L. microphylla*) ($P = 1.00$), treatments *versus* concentrations ($P = 0.44$), were not significant by the F test. However, the concentration variation factor ($P < 0.0001$) was significant at 1% probability by the F test.

When observing the probability curve of mortality of the predator *E. annulipes*, it is possible to observe in the treatment corresponding to the oil of *L. microphylla* a variation of 0 to 84% in the probability of mortality, that were respectively of the control and concentration treatments of 200 mg mL^{-1} (Figure 3). For *V. arborea* oil, a change from 0 (control) to 70% (concentration 200 mg mL^{-1}) was observed, in the occurrence of ring-legged earwing mortality. These results were similar to those found for the same treatments applied on *S. frugiperda*. It was observed that at concentrations higher than 150 mg mL^{-1} occurs the highest mortality rates.

The lethal concentrations of the essential oils of *V. arborea* and *L. microphyla* capable of killing 10% (LC_{10}) and 50% (LC_{50}) of the predator *E. annulipes* were evaluated (Table 2).

The essential oil of *V. arborea* had LC_{10} of 71.3 mg mL^{-1} and LC_{50} of 160.2 mg mL^{-1}, whereas *L. microphyla* oil had LC_{10} of 50.3 mg mL^{-1} and LC_{50} of 134.67 mg mL-^{1}. The morphological characterization of *E. annulipes* was also performed by means of an electronic magnifying glass, after verified its mortality by the essential oils of *V. arborea* and *L. microphyla* (Figure 4).

Similar to that observed for the fall armyworm, in the ring-legged earwing, the oils also showed a difference in their mechanism of action, because the morphological difference was visible when compared to the oils of *L. microphylla* (Figure 4A) and *V. arborea* (4B). The oil of *V. arborea* acted in the digestive tube of the fall armyworm, promoting the osmotic rupture of the epithelial cells making them look dark, as if in the process of putrefaction (Figure 4B). When comparing the action of the essential oils of *V. arborea* and *L. microphyla*, in the same concentrations in the insect-pest *S. frugiperda* and in its predator *E. annulipes*, by means of the Abbot efficiency, it is noticed that the two oils were more control of the fall armyworm, however, plant insecticides also promoted mortality to the predatory insect (Table 3).

The concentration of 200 mg mL^{-1} of the *V. arborea* and *L. microphyla* oils had an efficiency of 68 and 84% of mortality of the beneficial insect (Table 3). While this same concentration caused mortality of 80 and 90% of the fall armyworm.

4. Discussion

A similar effect was also observed by Silva et al. (2017), when studying the larvicidal action of the essential oil of *V. arborea* on *Aedes aegypti*. These researchers found that as the concentration of the oil increased, the efficiency of the product was proven to cause a higher mortality.

During the whole evaluation period no mortality of *S. frugiperda* was observed in the control treatment (water

Table 2. Minimum (LC_{10}) and average (LC_{50}) concentrations of the essential oils of *V. arborea* and *L. microphyla* on 3rd instar nymphs of *E. annulipes*.

Species	LC_{10} (CI 5%) mg mL^{-1}	LC_{50} (CI 5%) mg mL^{-1}
Vanillosmopsis arborea	71.30	160.20
	53.30 - 90.50	150.80 - 175.90
Lippia microphyla	50.30	134.67
	33.20 - 69.40	123.60 - 145.70

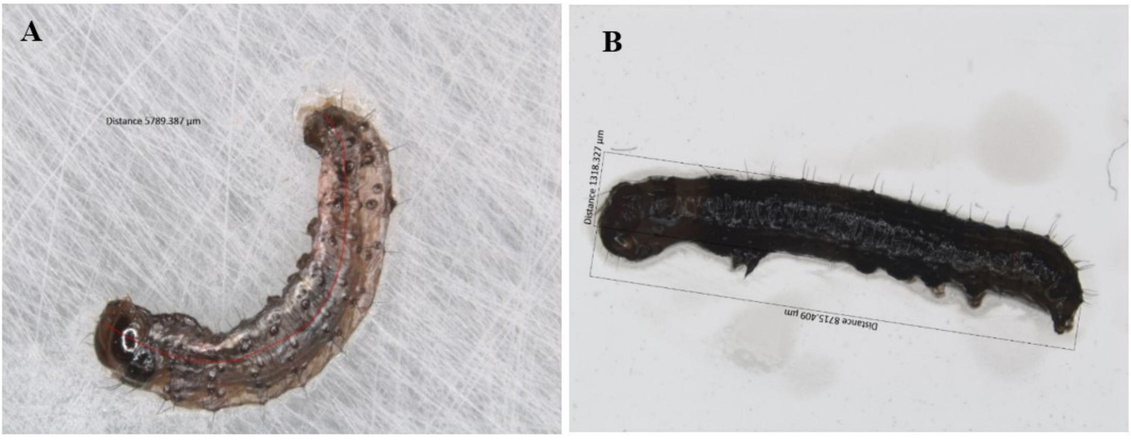

Figure 2. Morphological characterization of *S. frugiperda* treated with essential oils of *L. microphylla* (A) and *V. arborea* (B).

application + Tween® 80). For *V. arborea* and *L. microphyla* oils, the mortality of the fall armyworm was verified from the concentration of 50 mg mL^{-1}. *L. microphylla* oil caused 100% mortality at the highest concentration (200 mg mL^{-1}) and only about 65% mortality with application of *V. arborea* at the same concentration (Figure 3). The application of *L. microphylla* oil (30 mg g^{-1}) caused 100% mortality in *S. frugiperda* (Negrini et al., 2019).

Table 3. Efficiency of the essential oils of *V. arborea* and *L. microphyla* on 3rd instar of nymphs of *E. annulipes* and 3rd instar of *S. frugiperda*.

Treatments	Mortality Efficiency(%)		
	Concentration mg mL^{-1}	***E. annulipes***	***S. frugiperda***
Vanillosmopsis arborea	0	-	-
	50	12	20
	100	8	10
	150	56	30
	200	68	80
Lippia microphyla	0	-	-
	50	16	10
	100	24	40
	150	64	100
	200	84	90

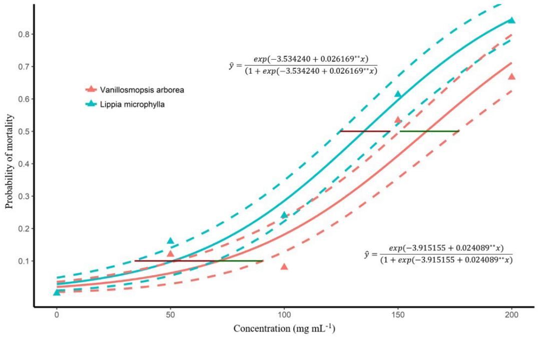

Figure 3. Probability of mortality of *E. annulipes* submitted to the essential oils of *V. arborea* and *L. microphyla.*

Essential oils of *V. arborea* and *L. microphyla* were as major compounds the constituents α-bisabolol and 1,8-cineole, respectively. These are the possible promoters of insect mortality. Lima et al. (2009b) carried out studies using the essential oil of guava leaves (*Psidium guajava* L.) on the behavior of the *S. frugiperda*. The same researchers found that the constitutive 1,8-cineole was one of the most important compounds, and the oil of *P. guajava* presented a pest repellency in the concentration of 0.01%.

When evaluating isolated compounds of trans-anethole, limonene and their combination in nutritional components and their action on reproductive parameters and testicular apoptosis in *S. frugiperda*, Cruz et al. (2017), concluded that limonene and trans-anethole, especially in association, cause adverse effects on nutrition and reproduction in *S. frugiperda*, changing parameters essential for their survival and establishment in crops.

Lima et al. (2010) evaluated the insecticidal activity of the essential oil of *Ageratum conyzoides* L. on *S. frugiperda*, by means of ingestion test, it was verified mortality of 70% of the pest from the concentration of 0.5%. Evaluating the bioactivity of essential oils of three eucalyptus species in the control of *S. frugiperda*, Souza et al. (2010), concluded that these oils presented topical toxicity. *C. citriodora* oil is more efficient because it caused a higher mortality rate. Lima et al. (2009a) evaluated the insecticidal activity of long chilli pepper essential oil (*P. hispidinervum*) on *S. frugiperda* and in this study, authors using 3rd instar fall armyworm obtained LC_{50} of 28.3 mg mL^{-1} in the first 24 hours of exposure from insect to treatments.

It is noted that there is morphological difference between the fall armyworm treated with the essential oils of *L. microphylla* (Figure 4A) and *V. arborea* (Figure 4B). Probably this may have happened because they can present different mechanisms of action, thus, it is suggested that the oil of *L. microphylla* (Figure 4A) has hypermeabilizado the spiracles of the fall armyworm, thus preventing its

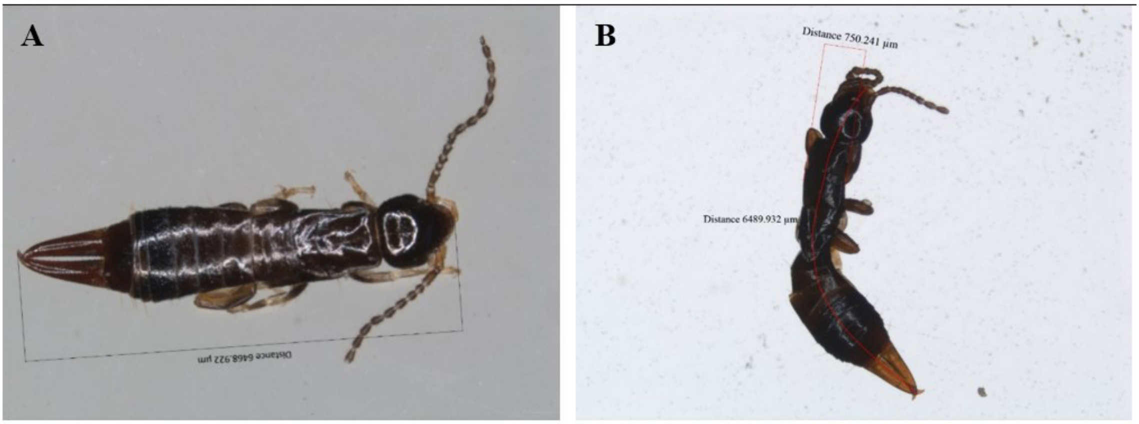

Figure 4. Morphological characterization of *E. annulipes* treated with essential oils of *L. microphylla* (A) and *V. arborea* (B).

respiration, causing it to be with wilted appearance. Castor oil contributed to the covering of the spiracles of *Diaphania nitidalis* caterpillars on pumpkin leaves treated with this oil, causing asphyxiation and consequently the death of the caterpillars (Lima et al., 2015). Some researchers have reported insect asphyxiation due to the blockage of spiracles as the main mode of action of mineral oils and, in some cases, as in the present research, of vegetable oils (Stadler and Buteler, 2009; Egwurube et al., 2010; Buteler and Stadler, 2011).

The research concerning the evaluation of the effect of the products of vegetal origin on beneficial insects has taken on importance due to the great number of substances that are being used in the control of insect pests. As studies on *E. annulipes* are rare, we have selected the evaluations with the main predatory insects. Evaluating the effects of botanical insecticides on the predator *Cycloneda sanguinea* L. in a cotton plant, Breda et al. (2011), concluded that insecticides based on azadirachtin, aqueous extract of neem seeds and castor oil were toxic to larvae of the 1^{st} instar of this predator, with mortality from 96.7 to 100% for azadirachtin and aqueous extract of neem, and 50 to 100% for castor oil. For the 4^{th} instar, mortality ranged from 87.5 to 100%.

Veronez et al. (2012), studying the toxicity of synthetic and natural compounds on *Tetranychus urticae* and the predator *Phytoseiulus macropilis*, found that extracts of *Allium cepa* L., *Agave angustifolia* Haw. and products based in neem oil caused mortality above 83% in *T. urticae*. The *A. angustifolia* extract did not cause significant mortality in *P. macropilis*, and did not significantly affect the growth rate of this predator. However, the *Laurus nobilis* L. extract severely affected the *P. macropilis* population.

Breda et al. (2011), studying the effects of botanical insecticides on the aphid *Aphis gossypii* and its predator *Cycloneda sanguinea*, have inferred that the insecticides based on azadirachtin, aqueous extract of neem seeds and castor oil are promising for the management of *A. gossypii*, but was not very selective to *C. sanguinea*, presenting toxicity to larvae of 1^{st} and 4^{th} instar of this predator. Evaluating the toxicity of the essential oil of *Lippia gracilis* and its main major compounds in *Diafania hyalinata*, *Apis mellifera* bees and predatory wasp *Polybia micans*, Melo et al. (2018) concluded that the treatments were not selective to *A. mellifera* and *P. micans*, however, due to the high toxicity of monoterpenes thymol and carvacrol, *L. gracilis* oil is a promising source for the synthesis of new insecticidal molecules. The plants studied in this work also appear as promising for the synthesis of compounds such as α-bisabolol and 1,8-cineole.

5. Conclusions

The essential oils of *Vanillosmopsis arborea* and *Lippia microphylla* have as main constituents the α-bisabolol and 1,8-cineole, respectively. The *V. arborea* and *L. microphylla* oils are efficient in the control of *Spodoptera frugiperda* being considered promising for the synthesis of new molecules for the development of synthetic botanical insecticides. *V. arborea* and *L. microphylla* were not selective to the predator *Euborellia annulipes* under laboratory conditions and in the concentrations used.

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