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CROP PROTECTION

Effect of anonaceous extracts on *Aphis gossypii* (Glover, 1887) (Hemiptera: Aphididae) and selectivity to *Eriopis connexa* (Germar, 1824) (Coleoptera: Coccinellidae)

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ABSTRACT. The effects of ethanolic and hexanic extracts of soursop and sugar apple (EES, EHS, EESA and EHSA, respectively) on *Aphis gossypii* (Hemiptera: Aphididae) and its natural enemy *Eriopis connexa* (Coleoptera: Coccinellidae) by contact exposure, residual effect and ingestion tests were evaluated. The estimated LC_{50} and LC_{99} values for *A. gossypii* were 0.39% and 5.47% for (EESA); 0.23% and 1.19% for (EES); 0.47% and 4.39% for (EHSA); and 0.42% and 6.38% for (EHS), respectively. Considering contact exposure, EES at 0.23% was innocuous, and EHS at 0.42% was slightly harmful; for adult ladybugs, only EESA (5.47%) was classified as slightly harmful, with the other treatments classified as harmless. The results were similar for the residual effect. For selectivity in ingestion tests, EES and EHS at the LC_{50} did not affect the survival rate of the predator, but EESA (0.39% and 5.47% for the LC_{50} and LC_{99}, respectively) reduced the survival rate to zero in less than 7 days, resembling chemical treatment with Decis®. Extracts applied to the eggs of an alternative prey reduced the consumption of eggs and therefore the predatory capacity of the ladybug, which led to a decrease in oviposition, egg viability and ultimately a reduction in predator fecundity. EES at a concentration of 0.23% was effective in the control of *A. gossypii* and was selective and did not affect the survival rate of the its natural enemy *E. connexa*.

Keywords: aphids; lethal concentrations; ladybug; *Annona squamosa*; *Annona muricata*.

Efeito de extratos de anonáceas para *Aphis gossypii* (Glover, 1887) (Hemiptera: Aphididae) e seletividade a *Eriopis connexa* (Germar, 1824) (Coleoptera: Coccinellidae)

RESUMO. Avaliou-se a eficiência dos extratos etanólicos e hexânicos de graviola e pinha (EEG, EHG, EEP e EHP) sobre *Aphis gossypii* (Hemiptera: Aphididae) e seu inimigo natural *Eriopis connexa* (Coleoptera: Coccinellidae), com testes de contato, efeito residual e ingestão. As CL_{50} e CL_{99} estimadas para *A. gossypii* foram respectivamente, 0,39 e 5,47% para (EEP); 0,23 e 1,19% para (EEG); 0,47 e 4,39% para (EHP); 0,42 e 6,38% para (EHG). Na ação por contato, o EEG a 0,23% foi inócuo, o EHG a 0,42% foi levemente nocivo; para adultos apenas o EEP (5,47%), foi classificado como levemente nocivo e os demais tratamentos como inócuos, inclusive para o efeito residual. Quanto à seletividade por ingestão, as CL_{50} do EEG e EHG não interferiram na taxa de sobrevivência dos predadores, mas o EEP (0,39 e 5,47%) reduziu a zero essa taxa em menos de 7 dias, assemelhando-se ao tratamento químico Decis®. Os extratos reduziram o consumo de ovos da presa alternativa, diminuindo a capacidade predatória e, com isso, diminuiu na oviposição, afetando a fecundidade do predador e a viabilidade dos ovos. O EEG na concentração de 0,23% foi eficiente no controle de *A. gossypii*, e seletivo ao inimigo natural *E. connexa*, não interferindo na taxa de sobrevivência destes.

Palavras-chave: afídeos; concentrações letais; joaninha; *Annona squamosa*; *Annona muricata*.

Introduction

Aphis gossypii (Glover, 1887) (Hemiptera: Aphididae) is a species of aphid widely distributed throughout the world but with higher incidence in the tropics. This aphid is polyphagous and described in association with more than 700 host plants worldwide. The importance of this pest is related to the direct damage caused by the sap sucking of plants and indirectly by the wrinkling of shoots and transmission of viruses to host crops (Guimarães, Moura, & Oliveira, 2013).

The primary control measure for this aphid is the use of synthetic insecticides registered in the Ministry of Agriculture (MAPA) (Lima, Costa, Araujo, Rugama, & Godoy, 2012). Applications of these insecticides are generally made preventively without respecting legal and technical recommendations for dosage, application frequency, grace period and rotation of chemical products. As a consequence, the beneficial biodiversity is impoverished and pests develop resistance (Shi et al., 2012).

To reduce the abusive use of agrochemicals, Integrated Pest Management (IPM) offers an alternative to the conventional agriculture model. The aim of IPM is to harmonize the various control tactics, including alternative pest control through the use of plants with insecticidal properties and biological control by protecting natural enemies using selective products.

Among the plants with insecticidal properties, those of the Annonaceae family are notable as they have shown many species with promising composts (Isman & Seffrin, 2014). The insecticidal potential of plants of this family is notable; however, little is known about their actions on the beneficial fauna, particularly on the natural enemies of pests.

Phytochemically, the family Annonaceae is known for the variable types of secondary metabolites. Chemotaxonomic data characterize this family by alkaloids, flavonoids and terpenoids, primarily diterpenes (Silva et al., 2009). Studies on the phytochemistry and biological activity of Anonnaceae have intensified with the identification of acetogenins (ACGs), which are a class of compounds with broad biological activity (Matsumoto, Ribeiro, Takao, & Lima, 2010), including cytotoxic, immunosuppressive, insecticidal, antiparasitic and antimicrobial properties (Lima, Pimenta, & Boaventura, 2010).

Several works related to pest control with botanical extracts emphasize that the use of these substances should be compatible with other management tactics, particularly with biological pest control, which is composed of one or more types of beneficial organisms, called natural enemies that reduce populations of plant pests (Parra, Botelho, Corrêa-Ferreira, & Bento, 2002).

As members of the complex of natural enemies of pests, ladybugs are recognized for their voracity and ability to search the prey. Among coccinellids, *Eriopis connexa* (Germar, 1824) (Coleoptera: Coccinellidae) is notable for the control of aphids and mites, characterized by high polyphagia and occurrence in several crops (Sarmento et al., 2004).

Thus, the aim of this work was to evaluate the effects of organic extracts of soursop *Annona muricata* L. and sugar apple *Annona squamosa* L. on the aphid *A. gossypii* and on the selectivity to its natural enemy *E. connexa*.

Material and method

The experiments were carried out in the Laboratory of Entomology: Alternative Pest Control of the Center for Agricultural Sciences of the Federal University of Alagoas - CECA / UFAL, Rio Largo, Alagoas State, Brazil.

Rearing of *Aphis gossypii*

The aphids were created following the methodology of Costa et al. (2011). Cotton seeds of the Acala 90 cultivar were sown in 500 mL plastic cups containing black soil and organic compost (60:40) placed in a greenhouse. Plants with 20 cm long were initially infested with aphids collected from okra and cotton fields.

Creation of the predator *Eriopis connexa*

Ladybugs were obtained from the Laboratory of Biological Control and Ecology of Insects at UFRPE. Adults and larvae were reared according to the methodology of Rodrigues, Spindola, Torres, Siqueira, and Colares (2013) and were fed with *Anagasta kuehniella* eggs and a pasty mixture of beer yeast and honey (50:50). Two larvae were kept per 80 mL plastic container, and adult ladybugs were confined in 500 mL plastic containers with lid openings covered with voile fabric to allow air circulation and pieces of paper towel as a substrate for laying eggs inside containers.

Seed collection and extract preparation

Soursop seeds were obtained from a fruit pulp processing industry established in Anadia, Alagoas State, Brazil, in 2014, and sugar apple seeds were collected from ripen fruits produced in the orchard of the Center for Agricultural Sciences of the Federal University of Alagoas in 2015. Hexanic (EHS) and ethanolic (EES) soursop extracts and hexanic (EHSA) and ethanolic (EESA) sugar apple extracts were prepared in the Laboratory of Research in Natural Products (LPqPN) of the Institute of Chemistry, Federal University of Alagoas.

Sugar apple and soursop seeds were cleaned in a solution of 10% sodium hypochlorite and oven-dried at 50°C for 7 days. Seeds were then grid to a fine uniform powder in a forage-grinding mill (mesh size 2.5 mm). The seed powder was submitted to cold extraction in a stainless steel percolator, first with hexane for 24 hours and, the resulting cake, was extracted with ethanol (EtOH) for 72 hours. Both extracts were filtered, concentrated in a rotary evaporator at 50°C under reduced pressure and packed in glass containers. The following yields were obtained for the crude extracts: 395 g for EHS and 230 g for EES, from 2.3 kg of soursop seeds; and 500 g EHSA and 353 g for EESA, from 3 kg of sugar apple seeds.

Toxicity of *Annona muricata* and *Annona squamosa* organic extracts to *Aphis gossypii*

To estimate lethal concentrations, preliminary tests were conducted with different concentrations of *A. muricata* and *A. squamosa* organic extracts to determine approximating values of the Upper Limit (UL) that would cause mortality near to 100% and the Lower Limit (LL) that would cause mortality approximating that of the control.

After determining the limits of extracts, eight different concentrations were evaluated: 0.125, 0.25, 0.3, 0.4, 0.5, 1.0, 1.5, and 2.0%, which corresponded to the a_1, $a_1.q$, $a_1.q^2$, $a_1.q^3$, $a_1.q^4$, and $a_1.q^5$ sequence obtained by the following formula (Bliss, 1934):

$$q = \left(\frac{a_n}{a_1}\right)^{\frac{1}{n+1}}$$

where: q = geometric progression ratio (gp); N = number of concentrations to be extrapolated; and a_n and a_1 = upper and lower limits, respectively, of the geometric progression.

Concentrations were prepared at the time of use by diluting concentrated extract in water and Tween 80 (0.05%).

Cotton leaf discs with 5 cm in diameter were cut and sprayed with the organic extracts in Potter's tower (Potter, 1952). Spray was applied at a pressure of 5 psi in^{-2} using a 2.3 mL spray volume, corresponding to a reservoir of 1.9 ± 0.37 mg cm^{-2}. After treatments, leaf discs dried naturally on paper towels and then were placed on a thin layer of agar gel (10 g of agar L^{-1} of distilled water) in 10 cm Petri dishes. Five aphids were inoculated per dish. After 24 hours, the aphid mortality rate was recorded.

Data were submitted to analysis of variance in the SAS statistical software package, and lethal concentrations (LC_{50} and LC_{99}) were estimated using Probit analysis.

Effect of extracts by contact on the mortality rate of *Eriopis connexa*

Eriopis connexa first instar larvae and adults were placed individually in Petri dishes containing filter paper discs at the bottom and sprayed with Potter's tower (Potter, 1952) with the LC_{50} and LC_{99} of soursop and sugar apple extracts (hexanic and ethanolic) estimated by Probit analysis for *A. gossypii*. The plates were sealed with plastic film, and 24 hours after spraying, mortality rates of larvae and adults were evaluated. The experiment was organized in a completely randomized design with eight treatments and 10 replicates.

Effect of extracts by ingestion on interference of the predatory capacity and oviposition of *Eriopis connexa* ladybugs

Five *E. connexa* couples were placed in Petri dishes lined with filter paper and daily fed with 10 mg of *A. kuehniella* eggs treated with distilled water (control treatment), with Decis® chemical insecticide (deltamethrin) (positive control) at the dose recommended to control cotton aphids (400 mL ha^{-1}) (Agrofit, 2016), and with the lethal concentrations estimated by the Probit analysis for *A. gossypii* (LC_{50} and LC_{99}) of soursop and sugar apple organic extracts. The study continued for 11 days, with a daily supply of new, freshly treated eggs with the respective treatments.

Eggs of *A. kuehniella* were sprayed in a Potter's tower calibrated to a volume of 2.3 ± 0.5 mL of each extract/cm^2. The mortality rate of *E. connexa*, daily egg consumption (predatory capacity), and the number of eggs laid and egg viability were evaluated.

All evaluations were performed using a stereoscopic magnifying glass, and the products tested were classified according to the selectivity standards of the International Working Group on Beneficial Organisms and Pesticides of the International Organization of Biological Control (IOBC), Western Palearctic Regional Section (WPRS) (Hassan, 1994). The classification of products was according to the following intervals: 1- innocuous (mortality < 30%), 2- slightly harmful (30 - 79%), 3- moderately harmful (80 - 99%), and 4- harmful (> 99% mortality) (Hassan, 1994).

Residual effect of extracts on *Eriops connexa*

Filter paper discs 8 cm in diameter were sprayed with the LC_{50} and LC_{99} estimated by Probit analysis for *A. gossypii* of each soursop and sugar apple extract in a Potter's tower calibrated to a volume of 2.3 ± 0.5 mL. The discs were placed to dry naturally and then were deposited in 10-cm Petri dishes. Ten first instar *E. connexa* larvae and 10 adults per dish were released on these discs, and the mortality rate of ladybugs was evaluated daily.

Result and discussion

Toxicity of extracts to *Aphis gossypii*

For EES, the Probit model was adjusted with a value of p = 0.78. The estimated lethal concentrations were 0.23% (ranging from 0.20 to 0.27%) for the LC_{50} and 1.19% (ranging from 0.82 to 2.37%) for the LC_{99}. For EHS, p = 0.36 for the model, and the estimated LC_{50} and LC_{99} were 0.42% (ranging from 0.34 to 0.54%) and 6.38% (ranging from 3.50 to 17.57%), respectively (Table 1).

When comparing extracts elaborated with different solvents in increasing order of polarity, extracts obtained from low polarity solvents such as hexane typically have excess fatty matter, with even more fat material in extracts from seeds. Such a high fat content can result in lower biological activity, because fatty material has less activity. This relation was also observed in the present study, with the LC_{99} of the hexanic soursop extract much higher than that of the ethanolic extract.

However, evaluating the effect of two doses (0.5 and 1.0%) of hexanic extracts of *A. muricata* seeds and leaves on the black aphid *A. craccivora*, Rodrigues, Valente, Lima, Trindade, and Duarte (2014) concluded that the hexanic extract of soursop seeds at the dose of 0.5% resulted in 98.9% control. This result shows that the solvent extractor may change the composition of the extract and that different target pests may also present a different response to their toxic activity.

For the extracts of sugar apple seeds, EESA was more toxic to *A. gossypii* because the concentration (0.39% v/v) required to cause 50% mortality of the population was lower than that of EHSA, with an LC_{50} of 0.47% (v/v). However, the LC_{99} values were 5.47% and 4.39% (v/v) for EESA and EHSA, respectively (Table 1).

Table 1. Lethal concentrations (LCs) of ethanolic and hexanic extracts of soursop and sugar apple on *Aphis gossypii*.

Treatment	n[1]	DF[2]	Slope ± SE	CL_{50} (%) (CI 95%)[3]	CL_{99} (%) (CI 95%)[3]	χ^2	p[4]
EES	175	5	2.40 ± 0.29	0.23 (0.39 –0.58)	1.19 (0.82 – 2.37)	2.44	0.78
EHS	200	6	1.98 ± 0.26	0.42 (0.34-0.54)	6.38 (3.50-17.57)	6.51	0.36
EESA	250	8	2.04 ± 0.26=	0.39 (0.32-0.48)	5.47 (3.16-13.54)	5.14	0.74
EHSA	225	7	2.40 ± 0.29	0.47 (0.39-0.57)	4.39 (2.72-9.34)	9.6	0.21

SE: Standard error; LC: Lethal concentration; X^2: Pearson's Chi-square test; EES: soursop ethanolic extract; EHS: soursop hexanic extract; EESA: sugar apple ethanolic extract; EHSA: sugar apple hexanic extract; [1]Number of insects. [2]DF: Degrees of freedom. [3]CI: Confidence interval. *P*: Probabily > 0,05.

These results are similar to those found by Chien-Yih et al. (2009) for the insecticidal potential of sugar apple seeds. These authors demonstrated effective control using concentrations of 0.125, 0.25, and 0.5% of sugar apple seed oil for the control of *Bemisia argentifolii* Bellows & Perring (Hemiptera: Aleyrodidae), *A. gossypii* and *Tetranychus kanzawai* Kishida (Acari: Tetranychidae), with the two highest concentrations causing 98 and 100% mortality of *A. gossypii*, respectively.

Rabelo and Bleicher (2014) evaluated the efficiency of ethanolic extracts of sugar apple and atemya on the black aphid, *A. craccicvora*, in cowpea and concluded that the extracts used in the bioassay were effective, causing mortality of 99.27 and 98.18%, respectively.

Effect of extracts by contact action on the mortality rate of *Eriopis connexa* larvae and adults

Organic extracts of soursop and sugar apple seeds were harmful to *E. connexa* larvae and adults, except for the 6.38% EHS, which was slightly harmful to larvae, and the 5.47% EESA, which was slightly harmful to larvae and adults.

For the correct use of bioinsecticides, the selectivity is extremely important. For example, in a study conducted by Gazola et al. (2009), the extract of *Chrysanthemum parthenium* (L.) caused total mortality of *Harmonia axyridis* adults (Pallas, 1773) (Coleoptera, Coccinellidae). Additionally, according to the authors, the commercial products used (Plant Clean, Pironin and Mineral Oil) had low selectivity to the adults of this predator.

For treatment with the chemical insecticide Decis®, the survival rate of the 1st instar larvae was not affected, showing selectivity; however, when tested on adults, the mortality rate was 50%. Therefore, the chemical was innocuous for larvae and slightly harmful to adults. These results are similar to those of Carmo et al. (2010) who found that insecticides like pyrethroids, gamma-cyhalothrin, bifenthrin, imidarcloprid, beta-cyfluthrin, organophosphates, acephate and cloropiriphos, killed adults insects of the parasitoid *Telenomus remus* that came in contact with the dry residue, and reduced their parasitism rate.

Residual effect of soursop and sugar apple extracts on *Eriopis connexa*

The ethanolic and hexanic extracts of soursop and sugar apple seeds were not toxic to *E. connexa* 1st instar larvae or adults and did not affect the survival rates at any concentration tested. Therefore, the residual effect of these extracts was classified as innocuous according to Hassan (1994).

In the literature, reports on the residual effect of botanical products on natural enemies are scarce. However, when determining the selectivity of a product, tests are required that submit insects to both maximum contact with the residues of the highest agronomic dose (persistence) and ingestion of contaminated food with doses of the product (Hassan, 1994).

Effect of ingestion of extracts on interference of the predatory capacity and oviposition of *Eriopis connexa* ladybugs

After 11 days of evaluation, the effects of EES and EHS concentrations of 2.3 and 4.2%, respectively, were similar to those of the control, and the survival rate of adult *E. connexa* females was not affected; thus, the effects were classified as innocuous (Hassan, 1994).

However, the EHSA concentration of 0.47% caused 40% decrease in survival rate between the second and fifth day of exposure to the extract, which was classified as slightly harmful (Figure 1A). The EESA concentration of 0.39% resulted in 100% mortality, causing death until the seventh day of exposure to the treatment, which was similar to the effect of the chemical insecticide Decis® that also caused total mortality of insects by the sixth day of the experiment and was classified as harmful (Figure 1A).

The effect of the EHS concentration of 6.38% was similar to the control and did not cause insect death during the 11 days of treatment. However, the EES concentration of 1.19% reduced the insect survival rate to 40% between the sixth and eighth day of exposure to treatment and was classified as slightly harmful (Figure 1B).

EHSA and EESA concentrations of 4.49 and 5.47%, respectively, reduced survival rate by 80% from day two and were classified as slightly harmful, but these concentrations also led to total insect mortality by the sixth day, similar to the mortality caused by Decis®, which was classified as harmful to the natural enemy (Figure 1B).

The soursop extract concentration required for the control of 50% of the *A. gossypii* population, as estimated by Probit analysis, was relatively low, which reflected the greater survival rate of the natural enemy, whereas the concentration of sugar apple extracts to control 50% aphid was relatively high, which reflected the greater toxicity rate to ladybugs, causing their death in only seven days.

In addition to the differences in activity on survival between the different soursop and sugar apple extract concentrations, the reduction in the survival rate could have also occurred because the experiments were conducted in a controlled environment, and using arenas that limited the mobility of insects and extracts that were sprayed on food daily could result in overexposure to products.

Based on the assumptions of IPM, the combined use of soursop extract at the concentration estimated to control 50% of the *A. gossypii* population with the release of predatory ladybugs is a possible strategy for pest control. Consistent with these results, Tavares et al. (2010) concluded that neem oil could be used in the control of *S. frugiperda* with low risk to reduce the population of the natural enemy *E. connexa*.

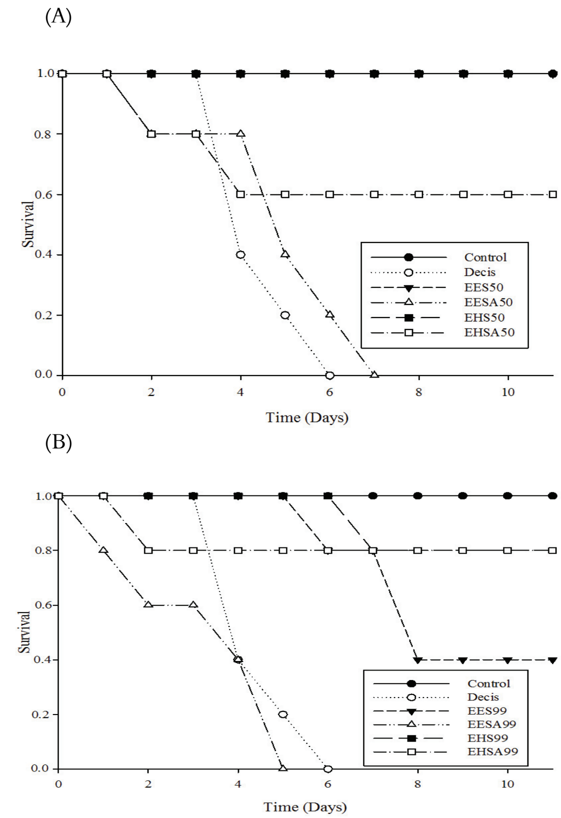

Figure 1. Survival of adult *Eriopis connexa* females after 11 days of ingestion of *Anagasta kuehniella* eggs treated with the Lethal concentrations (LC_{50}) (A) and (LC_{99}) (B) of soursop and sugar apple extracts: EES (soursop ethanolic extract) , EESA (sugar apple ethanolic extract), EHS (soursop hexanic extract), EHSA (sugar apple hexanic extract).

Concerning the effects of extracts on *E. connexa*, the ingestion of *A. kuehniella* eggs treated at all sugar apple and soursop extract concentrations resulted in lower egg consumption than that of the control group (75.63%), from 25 to 32% for low LCs and from 5.9 to 20.35% for high LCs (Table 2).

Treatment with the Decis chemical insecticide interfered with ladybug predatory capacity because egg consumption was reduced to 4.90%. Additionally, the fertility rate of ladybugs was reduced to zero because no oviposition occurred.

For oviposition of the predator, treatments with extracts significantly reduced the number of eggs laid and their viability after 11 days of evaluations (Table 2), resulting in decreased *E. connexa* fecundity. The control group laid an average of 29.20 eggs, differing from the other treatments.

Table 2. Effect of Lethal Concentrations (LC_{50} and LC_{99}) on *Anagasta kuehniella* egg consumption (%), number of eggs and viability of eggs (%).

Treatments	Consumption (%) ± SE	Number of eggs ± SE	Viability (%) ± SE	Mortality (%)	Class*
0.23% EES	30.72 ± 0.88 b	9.00 ± 0.26 b	34.49 ± 3.0 a	0.00	1
0.42% EHS	25.81 ± 0.93 b	8.60 ± 0.80 b	37.57 ± 3.18 a	0.00	1
0.39% EESA	27.81 ± 2.33 b	7.80 ± 0.18 b	40.7 ±1.07 a	100.00	4
0.47% EHSA	32.17 ± 2.37 b	9.60 ± 0.92 b	32.10 ±3.42 a	40.00	2
Decis®	4.90 ± 0.23 c	0.00 ± 0.00 c	0.00 ± 0.00 b	100.00	4
Control	75.63 ± 0.42 a	29.20 ± 1.30 a	54.59 ±7.72 a	0.00	1
CV	31.36	31.70	45,31	-	-
Treatments	Consumption (%) ± SE	Number of eggs ± SE	Viability (%) ± SE	Mortality (%)	Class*
1.19% EES	18.35 ± 0,89 b	0.00 ± 0.00 b	-	60.00	2
6.38% EHS	5.99 ± 0,57 c	0.00 ± 0.00 b	-	0.00	1
5.47% EESA	5.99 ± 0,57 c	0.00 ± 0.00 b	-	100.00	4
4.39% EHSA	20.35 ± 1,25 b	0.00 ± 0.00 b	-	20.00	1
Decis®	4.90± 0,23 c	0.00 ± 0.00 b	-	100.00	4
Control	75.63 ± 0,42 a	29.20 ± 1.30 a	54.59 ± 7.72	0.00	1
CV	23.91				

EES: soursop ethanolic extract ; EHS: soursop hexanic extract ; EESA: sugar apple ethanolic extract ; EHSA: sugar apple hexanic extract.
*Classes of toxicity according to the IOBC/WPRS: class 1 = $E < 30\%$ (innocuous, not harmful); class 2 = $30 < E < 80$ (slightly harmful); class 3 = $80 < E < 99$ (moderately harmful), and class 4 = $E > 99\%$ (harmful).

The viability of eggs in the control group at 54.59% was significantly different from all other treatments. However, at the LC_{50} concentrations of the extracts, egg viability was not significantly different at 40.07% for EESA, 37.55% for EHS, 34.49% for EES, and 32.10% for EHSA (Table 2).

Fecundity of the lady bug was negatively affected at the lethal concentrations, with oviposition significantly reduced at LC_{50} treatment and prevented throughout the experiment at the LC_{99} treatment, similar to the effect of the chemical insecticide (Table 2).

According to the classification of Hassan (1994), only EHSA was considered slightly harmful (Class 2), whereas the other extracts (EESA, EES and EHS) and Decis® chemical were considered harmful (Class 4), based on the parameters evaluated in this study. However, the experiments were conducted under laboratory conditions, and the data on the predatory capacity and fecundity of *E. connexa* were obtained following daily applications of extracts, which could have resulted in an overdose of the active ingredient, and these factors must be considered in evaluating the results. Furthermore, under field conditions, because of the mobility and diversity of prey, the effects of these botanical extracts might be minimized on the natural enemy.

Negative effects of botanical extracts on natural enemies, particularly on predatory ladybugs have been reported. For example, Venzon, Rosado, Pallini, Fialho, and Pereira (2007), evaluating the effects of 0.25 and 0.5% neem extract on *E. connexa* and the aphid *M. persicae*, observed that only 10% of ladybug larvae on pepper plants formed pupae, and no adults emerged.

Similarly, Ribeiro et al. (2009) evaluated the toxicity of tobacco powder (*Nicotiana tabacum*) and DalNeen® (commercial product based on Azadirachtin), both at concentrations of 5% and 10% (w/v and v/v, respectively), to *E. connexa* based on the ingestion of prey contaminated for 11 days, and although no significant difference in adult mortality and larval hatch was observed between treatment and control, the predatory capacity and fecundity of *E. connexa* were reduced.

Breda, Oliveira, Marques Ferreira, and Santana (2011) reported that botanical insecticides based on azadirachtin and aqueous extract of neem and castor oil at different concentrations applied on *A. gossypii* and its predator *C. sanguinea* on coloured cotton adversely affected the development of 1st and 4th instar larvae of the predator.

Cosme, Carvalho, and Moura (2007) also studied the harmful effect of neem and synthetic products on *C. sanguinea* ladybug eggs and larvae. The viability of eggs was reduced primarily by the insecticide lambda-cyhalothrin, but azadirachtin was harmful to the predator embryos, with effects as harmful as those observed for chlorpyrifos and teflubenzuron.

Conclusion

Soursop and sugar apple extracts were toxic to *A. gossypii* in lower lethal concentrations of EES and EHS.

EES and EHS showed no contact toxicity to 1st instar larvae and adult *E. connexa* at all tested concentrations.

The residual effect of all extracts was classified as innocuous.

At all tested concentrations, when contaminated eggs were ingested, the predatory capacity and fecundity of ladybugs were reduced by EES, EHS, EESA and EHSA.

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