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Short communication

Use of plant oils from the southwestern Amazon for the control of maize weevil

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ABSTRACT

The purpose of this study was to evaluate the insecticidal potential of oils obtained from plant species endemic to the southwestern Amazon region against the maize weevil (*Sitophilus zeamais* Motschulsky). We evaluated the mortality of insects treated with 11 plant oils. After the discriminant assays, concentration–mortality bioassays were conducted to evaluate the toxicity of each oil. The insects were treated with the oils, and mortality was assessed after 24 h. Each assay was performed in four replicates. The LC_{50} of the oils against *S. zeamais* ranged between 53.35% and 65.22% for the oils obtained from *Astrocaryum aculeatum* Meyer, *Copaifera* spp., *Carapa guianensis* Aublet, *Oenocarpus bataua* Mart., *Mauritia flexuosa* L., and *Orbignya phalerata* Mart. These oils exhibited consistency in their toxic activity and emerged as potential alternatives to be implemented in integrated pest management programs for stored product pests. The results of this investigation identified several plant species in the Amazonian flora with potential insecticidal properties.

1. Introduction

Maize weevil (*Sitophilus zeamais* Motschulsky) is one of the most destructive pests of stored grains worldwide. They can infest all types of cereal grains infesting stored flour and processed grain products (Suleiman et al., 2015; Zakka et al., 2015). They are mainly controlled with phosphine, organophosphates, and pyrethroids. However, the continuous and indiscriminate use of these products has led to the emergence of insect populations with high levels of resistance (Lorini et al., 2007; Pimentel et al., 2007; Corrêa et al., 2011). An alternative is the use of plant insecticides.

The Amazon rainforest is the largest natural reservoir of plant diversity in the world, and each of its distinct forest habitats has a rich and varied floristic population, often unique to a particular environment (Oliveira and Amaral, 2004). Despite the immense plant diversity in the Amazon, the insecticidal potential of the species occurring in the forest itself is little known because relevant studies have been published only in the last decade (Coitinho et al., 2006; Geris et al., 2008; Pereira et al., 2008; Sarria et al., 2011; Moreno et al., 2011, 2012; Lima-Mendonça et al., 2013).

From a toxicological point of view, the recognition of the insecticidal potential of the plant species investigated is important because of the diversity of secondary metabolites often found in plant insecticides (Santiago et al., 2005; Ambrozin et al., 2006; Geris et al., 2008; Sarria et al., 2011). These compounds are not required for the immediate survival of plant cells but serve as an evolutionary advantage for their survival and reproduction and can also serve as natural pesticides for defense against herbivores or pathogens (Moreno et al., 2011; Rani et al., 2011). Biological pesticides have different modes of action that can be associated with their potential toxicity, repellency, and the capacity to inhibit insect feeding, development, and reproduction (Wang et al., 2006; Santos et al., 2011).

Furthermore, plant-derived insecticides can be easily prepared and present lower risks to human health and the environment. However, their use requires the same precautions that are adopted in the use of synthetic insecticides because of the possible toxic effects on both mammals (Elvin-Lewis, 2005) and the natural enemies of pests (Suthisut et al., 2011). At first, efforts were made to evaluate the insecticidal potential of oils obtained from 11 plant species against the adults of *S. zeamais*.

2. Materials and methods

Insects were reared in 1.5-L glass containers under constant

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temperature (25 ± 2 °C) and relative humidity (70% ± 5%) in a 24-h scotophase. Corn grain was used as food substrate with 13% moisture content (wet basis). The grains were previously purged with phosphine and maintained at −18 °C to prevent reinfestation. Oils used in this study (Table 1) were obtained from the Technology Foundation of the State of Acre (*Fundação de Tecnologia do Estado do Acre*—FUNTAC), except for oils from *Platonia insignis* Mart., *Pentaclethara macroloba* Wild., and *Astrocaryum aculeatum* Meyer that were purchased from producers in Santa Bárbara do Pará, in the state of Pará.

Bioassays were performed in two stages. In the first stage, assays were performed to select oils with the most potent insecticidal activity and these would provide data that could be used to adjust the probit model. For this purpose, bioassays were performed with pure oils without any dilution. The experimental units were comprised petri dishes (9.0 cm in diameter and 1.5 cm in height) with the bottoms lined covered with filter paper moistened with 200 μL of each oil. Forty unsexed adult insects were placed on each plate that were then closed and maintained under constant temperature (25 ± 2 °C) and relative humidity (70% ± 5%) in a 24-h scotophase. Each assay was performed in four replicates. In the control treatment, the insects were placed on petri dishes moistened with 1 mL of each oil. Insect mortality was assessed after 24 h of bioassay performance and was confirmed after eight days.

The mortality ratios (arcsine square root transformation) obtained in the bioassays with the oils were submitted to a two-way analysis of variance (ANOVA) and three-way ANOVA to determine the effects of the oils on mortality (PROC GLM; SAS Institute, 2011) followed by the Scott–Knott cluster analysis where necessary ($P < 0.05$) (Scott and Knott, 1974; Ferreira, 2011). The toxicity of the oils against *S. zeamais* was demonstrated by graphs with error bar using the SigmaPlot version 13.1 (Systat Software, Inc., San Jose, CA, USA).

Concentration–mortality bioassays were performed to evaluate toxicity. Initially, preliminary tests were conducted to estimate the highest concentrations at which insect death would not occur (lower end) and the lowest concentrations at which the highest mortality would occur (upper end). Based on the data obtained, five concentrations were established for each oil analyzed for use in the final bioassays using 200 μL of each oil concentration. The same experimental units of the tests conducted for oil screening were used, and each assay was performed in four replicates. Insect mortality was assessed after 24 h of bioassay performance and was confirmed after eight days.

The concentration–mortality data was subjected to probit analysis (PROC PROBIT; SAS Institute, 2011). Confidence intervals for the toxicity ratios were calculated following Robertson and Preisler (1992), and values of the lethal concentrations (LCs) were considered significantly different if their 95% confidence intervals did not encompass the value 1.

Table 1
List of plants used to obtain the oils evaluated.

Common name	Scientific name	Family
Andiroba	*Carapa guianensis* Aublet	Meliaceae
Angico	*Anadenanthera colubrina* Vellozo	Leguminosae
Assa-peixe	*Vernonia polysphaera* Less.	Asteraceae
Babaçu	*Orbignya phalerata* Mart.	Arecaceae
Bacuri	*Platonia insignis* Mart.	Clusiaceae
Buriti	*Mauritia flexuosa* L.	Arecaceae
Copaíba	*Copaifera* sp.	Leguminosae
Patauá	*Oenocarpus bataua* Mart.	Arecaceae
Pequi	*Caryocar brasiliense* Camb.	Caryocaraceae
Pracaxi	*Pentaclethara macroloba* Wild.	Leguminosae
Tucumã	*Astrocaryum aculeatum* Meyer	Arecaceae

3. Results

Insect mortality significantly varied between the plant oils ($F_{10;29} = 9.02$; $P < 0.001$) (Fig. 1). The mortality rates obtained using the oils from *A. aculeatum*, *Copaifera* spp., *Carapa guianensis* Aublet, *Oenocarpus bataua* Mart., *Mauritia flexuosa* L., *Orbignya phalerata* Mart., *P. insignis*, *Caryocar brasiliense* Camb., and *Anadenanthera colubrina* Vellozo were significantly higher than those obtained using the oils from *P. macroloba* and *Vernonia polysphaera* Less. However, only the mortality data of the oils obtained from *A. aculeatum*, *Copaifera* spp., *C. guianensis*, *O. bataua*, *M. flexuosa*, and *O. phalerata* were used to adjust the probit model (Table 2).

The probit model was suitable for the concentration-mortality data obtained with the oils based on the low χ^2 and high *P*-values obtained for each concentration-mortality curve ($\chi^2 < 4.8$; $P > 0.05$) (Table 2). The LC_{50} of the oils ranged between 53.35% and 65.22% and LC_{95} ranged between 63.93 and 80.88%. The toxicity ratio of oils exhibited negligible variation among them ranging from 1.0 to 1.22-fold at LC_{50} and from 1.0 to 1.27-fold at LC_{95}. In contrast, there was significant slope variation among oils, ranging from 15.84 to 28.11, indicating toxicological heterogeneity between some oils (e.g., *C. guianensis* and *Copaifera* sp.).

4. Discussion

This screening study indicates the wealth of plants with insecticidal properties occurring in the southwestern Amazon. This is the first study to report the insecticidal activity of oils from

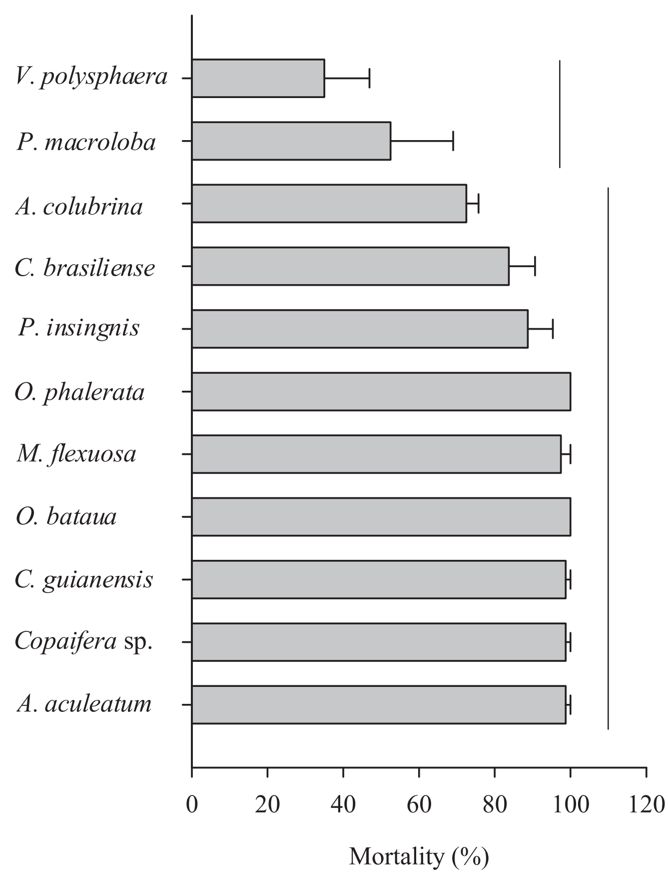

Fig. 1. Mortality rates (%) of adults of *S. zeamais* treated with plant oils. Averages grouped with bars at different periods indicate significant differences using the Scott–Knott test ($P < 0.05$).