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## Screening of plant extracts and fractions on *Aedes aegypti* larvae found in the state of Mato Grosso do Sul (linnaeus, 1762) (culicidae)

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### ABSTRACT

The constant use of chemical insecticides for *Aedes aegypti* control has caused resistance in the mosquito populations. Thus, the objective of this study was to analyze the larvicidal potential of extracts and fractions of plants on *A. aegypti* larvae. The analysis included sixty one extracts and twenty five fractions of fifty botanical species at concentrations of 0.25; 0.12; 0.06 to 0.03 mg mL<sup>-1</sup>; 4 replications and one negative control of dechlorinate water and 1% DMSO; and a positive control with rotenone. The toxicity index in descending order with LC<sub>50</sub> for the most active of the extracts selected were ethanol extract of *Ormosia arborea* (0.111 mg mL<sup>-1</sup>) seeds and ethanol extracts of leaves such as *Piper hispidum* (0.169 mg mL<sup>-1</sup>), *Solanum variable* (0.188 mg mL<sup>-1</sup>), *O. arborea* (0.238 mg mL<sup>-1</sup>), *Turnera umifolia* (0.242 mg mL<sup>-1</sup>) and *Piper hispidum* (0.567 mg mL<sup>-1</sup>). For plant fractions, the most active were chloroform (0.192 mg mL<sup>-1</sup>) and hexane (0.342 mg mL<sup>-1</sup>) *P. aduncum* leaves, hexane fraction (0.415 mg mL<sup>-1</sup>) and methanol extract (0.625 mg mL<sup>-1</sup>) of *Spermacoce latifolia* leaves. Regarding the extract of *T. umifolia* single species, there is no bibliographic report on their degree of efficiency as an insecticide.

**Key words:** Dengue fever, insecticidal activity, insecticide from plant, larvicidal potential, disease vector.

### INTRODUCTION

Brazil is considered an endemic area for dengue, which is transmitted by the mosquito *Aedes aegypti* (L.) (Culicidae) (Maciel et al. 2008). Dengue fever in Brazil, since 1986, has reached about 3 million cases. Only in the State of Mato Grosso do Sul, the year 2007 witnessed the largest outbreak of dengue

fever (69,378 reports), with the city of Campo Grande recording the largest number of cases per capita ever reported in a state capital (44,695 cases), meaning one case per 16 residents (Oliveira et al. 2009).

Each year it is estimated that infections with dengue virus are responsible for more than 100 million of classic cases and more than 500 thousand cases of hemorrhagic dengue fever worldwide (Halstead 2007). In Brazil, from January to July

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2010, 942,153 cases were reported in the country. In the same period of the previous year, 593,669 cases were reported, representing an increase of 58.7%. The states with the highest incidence were Acre (3,619.5 cases per 100,000 inhabitants), Mato Grosso do Sul (2,521.1 cases per 100,000 inhabitants), Goiás (1,353.1 cases per 100,000 inhabitants), Rondônia (1,256.4 cases per 100,000 inhabitants), Roraima (1,146.9 cases per 100,000 inhabitants) and Mato Grosso (1,095.5 cases per 100,000 inhabitants). These six states make up 75% of cases in Brazil (Oliveira et al. 2011).

The safest way to combat or prevent a virus is immunization. However, other measures have been employed in the control and against vector spread, such as environmental sanitation, epidemiological surveillance, laboratory and research support, and education (Teixeira et al. 2009).

A current form of control is fogging insecticides such as organophosphate and pyrethroid, but their continuous use has resulted in resistance of populations (Guirado and Bicudo 2009) and exposure of operators (Vilela et al. 2010) to the compounds. These effects have been reported in Latin American countries, decreasing the effectiveness of this strategy in mosquito control (Rodríguez and Fernández 2007).

Chemical control with organophosphates proved to be inefficient in combating the mosquito. Among the organophosphates, temephos was reported as *Aedes*-resistant by Melo-Santos et al. (2010). Malathion and fenitrothion, which are used for controlling the adult stages of *Aedes*, are encountering resistance in different degrees (Pontes et al. 2005).

Concerns about the possible impacts on the environment and population health have allowed the development of products based on plants as an alternative to the use of synthetic chemicals (Oliveira Filho 2008). Studies have been developed to obtain products from plants with insecticidal properties (Furtado et al. 2005, Garcez et al. 2013).

In this study, we analyzed the insecticidal potential of plant extracts and fractions found in Mato Grosso do Sul on larvae of *A. aegypti*.

## MATERIALS AND METHODS

### SOURCE OF PLANT MATERIAL

Fifty plant species were collected from 1999 to 2012. Forty-eight came from different regions of the Cerrado and Pantanal in Mato Grosso do Sul and two exotic species from Campo Grande -MS (*Melia azedarach* L. e *Nerium Oleander* L.). The voucher specimens were sent to identification to the herbarium of Anhanguera – Uniderp University (by Eloty Justina Dias Schleder) and Federal University of Mato Grosso do Sul (by Vali Joana Pott and Arnildo Pott).

The plants subjected to the experiment in different extracts were: *Anacardium humile* St. Hil.; *Arachis hypogaea* L.; *Baccharis dracunculifolia* DC.; *Bambusa multiplex* Lour. Raeusch.; *Bambusa vulgaris* var *vittata* Schrad. ex J.C. Wendl.; *Bauhinia fortificata* Link.; *Casearia silvestri* Sw.; *Chenopodium ambrosioides* L.; *Cochlospermum regium* Mart. ex Schrank Pilq.; *Combretum leprosum* Mart.; *Crescentia cujete* L.; *Cymbopogon citratus* (D.C.) Stapf.; *Diodia kuntzei* K. Shum.; *Dimorphandra* sp. Schott.; *Equisetum pyramidale* L.; *Genipa americana* L.; *Guazuma ulmifolia* Lamarck; *Jacaranda cuspidifolia* Marth.; *Lafoensia pacari* A. ST.-Hil.; *Leucaena leucocephala* (Lamarck) de Wit; *Maclura tinctoria* (L.) D. Don ex Steud.; *Melia azedarach* L.; *Malpighia glabras* Linn; *Myracrodruon urundeuva* Allemão; *Nerium oleander* L.; *Osmosea arborea* Vell; *Paullinia grandiflora* St. Hill; *Phoradendron* sp. Nutt.; *Piper aduncum* L.; *Piper amalago* L.; *Piper glabratum* Kunt.; *Piper hispidum* Sw.; *Piper vicosanum* Yunk; *Pouteria ramiflora* (Mart.) Radlk; *Randia armata* Sw (DC); *Richardia brasiliensis* Gomes; *Sebastiania hispida* (Mart.) Pax; *Solanum variabile* Mart.; *Spermacoceia verticillata* L.; *Spermacoceia*

*grisebachii* L.; *Spermacoea latifolia* L.; *Stachytarpheta cayennensis* Rich. Vahl; *Sterculia apetala* (Jacq.) H. Krast; *Struthanthus flexicaulis* M.; *Tamarindus indica* L.; *Tibouchina granulosa* (Desr.) Cogn.; *Tithonia diversifolia* (Hemsl.) A. Gray; *Turnera ulmifolia* L.; *Vernonia brasiliensis* L. (Druce); *Vigna angularis* Willd.

#### PREPARATION OF EXTRACTS

The plant material (leaves, stems, roots and fruits) were dried in an oven at 45 °C. The extraction with different solvents occurred by continuous maceration until exhaustion of the plant extract, the solvent was then removed via rotary evaporator and concentrated to obtain a homogeneous emulsion. Part of the extracts were dissolved in methanol/water and partitioned with solvents of different polarities (hexane, dichloromethane, chloroform and/or ethyl acetate).

The extracts and fractions of the species are presented in Table I. The descriptions are established in accordance with the updated nomenclature by the List of Species of the Brazilian Flora (2013).

#### EXPERIMENTAL COLONY

Collections of *A. aegypti* eggs were made in five neighborhoods in the city of Campo Grande, Mato Grosso do Sul, in partnership with the Center for Zoonosis Control (CCZ) using adapted methodology (Miyazaki et al. 2009, Gomes et al. 2007). The eggs were subjected to incandescent lighting for seven days until maturity. After that, F1 generation was produced and bioassays were conducted (Barata et al. 2001, Shaalan et al. 2005, Pontes et al. 2005).

The eggs were subjected to hatching in dechlorinate water and kept in Biochemical Oxygen Demand (BOD) incubator at  $27 \pm 2$  °C and 14-hour photoperiod. The larvae were fed with cat food and water was daily replaced, as well as pH checked. In the adult stage, females were fed

with blood supply every three days for 1.5 hours and males with 8% sugary food.

#### BIOASSAYS

Third stage larvae were selected for the testing, with larval density of 1:1 larvae/mL extract dissolved in dimethyl sulfoxide (DMSO) at 1%. A negative control group of larvae was submitted to only dechlorinate water and DMSO at 1% and a positive control group to rotenone concentration from 0.002 to 0.020 mg mL<sup>-1</sup> for 10, 50 and 90% of the exposed population group. The analysis was performed in quadruplicate.

Samples of each extract were dissolved in 1% DMSO to obtain a solution of 0.5 mg mL<sup>-1</sup>. It was initially used for the preliminary tests with two replications per species for a toxicity general testing and then in dilutions of 0.25; 0.12; 0.06 and 0.03 mg mL<sup>-1</sup> in quadruplicate. The test results were checked after 24 hours of exposure.

#### STATISTICAL ANALYSIS

For the analysis of toxicity testing (LC<sub>10</sub>, LC<sub>50</sub> and LC<sub>90</sub>), parametric regression method Probit (McLaughlin 1991) was performed using Leora software (POLO 9735947870655352).

#### RESULTS AND DISCUSSION

The results of toxicity testing for larvae of *A. aegypti* at 0.5 mg mL<sup>-1</sup> in 61 extracts, 25 fractions and 50 plant species are presented in Table I.

The extracts of *S. grisebachii*, *B. dracunculifolia* and *G. americana* showed larvicidal activity capable of causing death in 30% of the population at concentration of 0.5 mg mL<sup>-1</sup>. However, these extracts did not result in mortality at lower concentrations and hindered the calculation of LC<sub>50</sub>.

The extracts of *O. arborea*, *T. ulmifolia* and *S. variabile*, as well as extracts and fractions of *P. aduncum* L., *P. hispidum* L. and *S. latifolia* caused

**TABLE I**  
**Activity of plant extracts on *Aedes aegypti* larvae at concentration of 0.5 mg mL<sup>-1</sup>.**

Species	Popular name	Plant organ	Extract (Ext.)/ Fraction (Fr.)	Death Percentage
Amaranthaceae (1)				
<i>Chenopodium ambrosioides</i> L.	<i>Erva de Santa Maria</i>	Leaves	Ethanollic ext.	-
Anacardiaceae (2)				
<i>Anacardium humile</i> St. Hil	<i>Cajuzinho do Cerrado</i>	Leaves	Ethanollic ext.	up to 30
			Hexane fr.	-
<i>Myracrodruon urundeuva</i> Allemão	<i>Aroeira</i>	Leaves		-
		Twig	Ethanollic ext.	-
Apocynaceae (3)				
<i>Nerium Oleander</i> L.	<i>Espirradeira</i>	Leaves	Chloroform fr.	-
Asteraceae (4)				
<i>Baccharis dracunculifolia</i> DC.	<i>Vassourinha</i>	Leaves	Ethanollic ext.	up to 30
			Ethanollic ext.	-
<i>Tithonia diversifolia</i> (Hemsl.) A. Gray	<i>Margaridão, Girassol mexicano</i>	Twig	Hexane fr.	-
<i>Vernonia brasiliiana</i> L. (Druce)	<i>Assa-peixe</i>	Leaves	Ethanollic ext.	-
		Stems		-
Bignoniaceae (5)				
<i>Crescentia cujete</i> L.	<i>Árvore de cuia, cabaça</i>	Leaves	Ethanollic ext.	-
				-
<i>Jacaranda cuspidifolia</i> Marth.	<i>Caroba</i>	Stems	Dichloromethane fr.	-
		Leaves	Hexane fr.	-
Bixaceae (6)				
<i>Cochlospermum regium</i> Mart. ex Schrank Pilq.	<i>Algodão-do-campo</i>	Leaves		-
		Twig	Ethanollic ext.	-
		Tubercle		-
		Leaves	Ethyl acetate fr.	-
		Leaves		-
		Twig	Hexane fr.	-
		Tubercle		-

TABLE I (continuation)

Species	Popular name	Plant organ	Extract (Ext.)/ Fraction (Fr.)	Death Percentage
Combretaceae (7)				
<i>Combretum leprosum</i> Mart.	<i>Carne-de-vaca</i>	Leaves aerial parts		-
Equisetaceae (8)				
<i>Equisetum pyramidale</i> L.	<i>Cavalinha</i>	aerial parts	Ethanollic ext.	-
			Methanolic ext.	-
Euphorbiaceae (9)				
			Ethanollic ext.	-
			Hexane fr.	-
<i>Sebastiana hispida</i> (Mart.) Pax	<i>Erva virgem</i>	Leaves	Ethyl acetate fr.	-
			Methanolic fr. hydro	-
Fabaceae (10)				
<i>Arachis hypogaea</i> L.	<i>Amendoim</i>	Leaves	Ethanollic ext.	-
		Twig		-
<i>Bauhinia fortificata</i> Link.	<i>Pata-de-vaca</i>	Leaves	Ethanollic ext.	-
			Ethanollic ext.	-
<i>Dimorphandra</i> sp. Schott.	<i>Faveiro</i>	Fruits	Hexane fr.	-
			Ethyl acetate fr.	-
<i>Leucaena leucocephala</i> (Lamark) de Wit	Leucena	Leaves	Ethanollic ext.	-
		Twig		-
<i>Osmosea arborea</i> Vell	<i>Dracena</i>	Leaves	Ethanollic ext.	100
		Seeds		100
<i>Tamarindus indica</i> L.	<i>Tamarindo</i>	Leaves	Ethanollic ext.	-
<i>Vigna angularis</i> Willd.	<i>Feijão azuki</i>	Leaves	Ethanollic ext.	-
Flacourtiaceae (11)				
<i>Casearia silvestri</i> Sw	<i>Chá-de-frade</i>	Leaves	Ethanollic ext.	-
Lythraceae (12)				
<i>Lafoensia pacari</i> A. ST.-Hil.	<i>Mangabeira-brava</i>	Leaves	Ethanollic ext.	-
Loranthaceae (13)				
<i>Struthanthus flexicaulis</i> M.	<i>Erva de passarinho</i>	Leaves	Ethanollic ext.	-
Meliaceae (14)				
<i>Melia azedarach</i> L.	<i>Cinamomo</i>	Leaves	Ethanollic ext.	-
Malpighiaceae (15)				
<i>Malpighia glabras</i> Linn	<i>Acerola</i>	Leaves	Ethanollic ext.	-

TABLE I (continuation)

Species	Popular name	Plant organ	Extract (Ext.)/ Fraction (Fr.)	Death Percentage
Melastomataceae (16)				
<i>Tibouchina granulosa</i> (Desr.) Cogn.	<i>Quaresmeira</i>	Leaves	Ethanol ext.	-
Moraceae (17)				
<i>Maclura tinctoria</i> (L.) D. Don ex Steud.	<i>Amora brava, taiúva</i>	Leaves Twig	Ethanol ext.	-
Piperaceae (18)				
			Ethyl acetate fr.	100
<i>Piper aduncum</i> L.	<i>Pimenta de macaco</i>	Leaves	Chloroform fr.	100
			Hexane fr.	100
<i>Piper amalago</i> L.	<i>Jaborandi</i>	Leaves	Methanol ext.	-
			Hexane fr.	-
<i>Piper glabratum</i> Kunt.	<i>Piraparoba</i>	Leaves	Ethanol ext.	-
<i>Piper hispidum</i> Sw.	<i>Jaborandi falso</i>	Leaves	Methanol ext.	100
			Hexane fr.	100
<i>Piper vicosanum</i> Yunk	<i>Jaborandi</i>	Leaves	Ethanol ext.	-
Poaceae (19)				
<i>Bambusa multiplex</i> Lour. Raeusch.	<i>Bambu</i>	Leaves	Ethanol ext.	-
<i>Bambusa vulgaris</i> var <i>vittata</i> Schrad. ex J. C. Wendl	<i>Bambu</i>	Leaves	Ethanol ext.	-
<i>Cymbopogon citratus</i> (D.C.) Stapf.	<i>Capim Citronela</i>	Leaves	Ethanol ext.	-
Rubiaceae (20)				
			Methanol ext.	-
<i>Diodia kuntzei</i> K. Shum	<i>Planta aquática do Pantanal</i>	Leaves	Ethanol ext.	-
			Aqueous fr.	-
<i>Genipa americana</i> L.	<i>Genipapo</i>	Leaves	Ethanol ext.	up to 30
		Fruits		up to 30
<i>Randia armata</i> Sw (DC)	<i>Fruta de cachorro,</i>	Leaves	Methanol ext.	-
<i>Richardia brasilienses</i> Gomes	<i>Erva-botão</i>	Leaves	Ethanol ext.	-
<i>Spermacoea grisebachii</i> L.	<i>Agrião-do-campo</i>	Leaves	Methanol ext.	up to 30
			Methanol ext.	100
<i>Spermacoea latifolia</i> L.	<i>Agriãozinho</i>	Leaves	Hexane fr.	100
<i>Spermacoea verticillata</i> L.	<i>Vassourinha de botão</i>	Leaves	Ethanol ext.	—
Santalaceae (21)				
		Twig	Ethanol ext.	-
<i>Phoradendron</i> sp. Nutt.	<i>Erva-de-passarinho</i>	Twig	Aqueous fr.	-
		Leaves	Ethanol ext.	-



TABLE I (continuation)

Species	Popular name	Plant organ	Extract (Ext.)/ Fraction (Fr.)	Death Percentage
Sapindaceae(22)				
<i>Paullinia grandiflora</i> St. Hill	<i>Timbó</i>	Leaves	Methanolic ext.	-
		Twig		-
		Seeds		-
Sapotaceae (23)				
<i>Pouteria ramiflora</i> (Mart.) Radlk	<i>Leitero preto, abiu</i>	Leaves	Ethanollic ext.	-
Solanaceae (24)				
<i>Solanum variabile</i> Mart.	<i>Jurubeba</i>	Leaves	Ethanollic ext.	100
Sterculiaceae (25)				
<i>Guazuma ulmifolia</i> Lamarck	Chico magro	Leaves	Ethanollic ext.	-
		Twig	Ethanollic ext.	-
<i>Sterculia apetala</i> (Jacq.) H.Krast	<i>Mandovi, Amendoim-de-bugre</i>	Leaves	Aqueous fr.	-
		Leaves	Methanolic ext.	-
Turneracea (26)				
<i>Turnera ulmifolia</i> L.	Erva damiana	Leaves	Ethanollic ext.	100
Verbenaceae (27)				
<i>Stachytarpheta cayennensis</i> Rich. Vahl	Gervão	Leaves	Ethanollic ext.	-
		Twig	Ethanollic ext.	-
		Leaves	Aqueous fr.	-

\*30%: percentage of minimum mortality for testing with toxicity indicative in plant extracts at different concentrations as established by McLaughlin (1991).

total mortality at a concentration of 0.5 mg mL<sup>-1</sup> (Table I) and lethal concentrations (LC) at lower dilutions (Table II).

The ethanolic extract of *O. arborea* seeds (LC<sub>50</sub> 0.111 mg mL<sup>-1</sup>) was the most toxic showing high mortality at lower concentrations, followed by ethanolic extracts of *P. hispidum* (0.169 mg mL<sup>-1</sup>), *S. variable* (0.188 mg mL<sup>-1</sup>), *O. arborea* (0.238 mg mL<sup>-1</sup>), *T. umifolia* (0.242 mg mL<sup>-1</sup>) and *P. hispidum* (0.567 mg mL<sup>-1</sup>) leaves. The most active fractions were chloroform (0.192 mg mL<sup>-1</sup>) and hexane (0.342 mg mL<sup>-1</sup>) of *P. aduncum* leaves; and hexane fraction (0.415 mg mL<sup>-1</sup>) and methanol extract (0.625 mg mL<sup>-1</sup>) of *S. latifolia* leaves (Table II).

Govindarajan (2009) reported that the *Cassia fistula* leaf extract (Fabaceae) holds larvicidal and ovicidal action for *A. aegypti*, as well as a repellent in the peridomestic environment. Similar studies with *Casealpina ferrea* (Fabaceae) seeds presented larvicidal activity with 85% efficiency for vectors of dengue and yellow fever (Cavalheiro et al. 2009).

Derivatives of the emulsion composed of different species of *Copaifera* showed insecticidal activity against vectors of *A. aegypti* and *A. darlingi*. The lethal concentrations for *A. aegypti* of *Copaifera* sp. LC<sub>50</sub> showed values of 47 mg L<sup>-1</sup> and LC<sub>90</sub> 91 mg L<sup>-1</sup>. For *C. guianensis*, the values were



**TABLE II**  
**Lethal Concentration (LC) in mg mL<sup>-1</sup> for the different extracts of *Aedes aegypti* larvae.**

Plant species	Lethal Concentration	Average value in correlation 95% (mg mL <sup>-1</sup> )	Range limit in correlation 95% (mg mL <sup>-1</sup> )		
<i>Ormosia arborea</i> Vell <sup>A</sup>	LC <sub>10</sub>	0.164	0.133	-	0.185
	LC <sub>50</sub>	0.238	0.216	-	0.266
	LC <sub>90</sub>	0.347	0.307	-	0.429
<i>Ormosia arborea</i> Vell <sup>B</sup>	LC <sub>10</sub>	0.063	0.050	-	0.073
	LC <sub>50</sub>	0.111	0.098	-	0.124
	LC <sub>90</sub>	0.194	0.168	-	0.239
<i>Spermacoceae latifolia</i> L. <sup>C</sup>	LC <sub>10</sub>	0.191	0.125	-	0.245
	LC <sub>50</sub>	0.415	0.341	-	0.512
	LC <sub>90</sub>	0.901	0.690	-	1.441
<i>Spermacoceae latifolia</i> L. <sup>D</sup>	LC <sub>10</sub>	0.125	0.118	-	0.148
	LC <sub>50</sub>	0.625	0.618	-	0.653
	LC <sub>90</sub>	1.122	1.178	-	1.153
<i>Solanum variabile</i> Mart. <sup>A</sup>	LC <sub>10</sub>	0.097	0.062	-	0.124
	LC <sub>50</sub>	0.188	0.153	-	0.232
	LC <sub>90</sub>	0.284	0.249	-	0.581
<i>Piper aduncum</i> L. <sup>C</sup>	LC <sub>10</sub>	0.122	0.118	-	0.190
	LC <sub>50</sub>	0.342	0.206	-	0.401
	LC <sub>90</sub>	0.473	0.414	-	0.670
<i>Piper aduncum</i> L. <sup>E</sup>	LC <sub>10</sub>	0.034	0.035	-	0.042
	LC <sub>50</sub>	0.192	0.188	-	0.195
	LC <sub>90</sub>	0.346	0.340	-	0.350
<i>Piper hispidum</i> Sw. <sup>A</sup>	LC <sub>10</sub>	0.060	0.477	-	0.721
	LC <sub>50</sub>	0.169	0.169	-	0.189
	LC <sub>90</sub>	0.474	0.403	-	0.582
<i>Piper hispidum</i> Sw. <sup>E</sup>	LC <sub>10</sub>	0.320	0.264	-	0.366
	LC <sub>50</sub>	0.567	0.501	-	0.665
	LC <sub>90</sub>	1.003	0.818	-	1.410
<i>Turnera ulmifolia</i> Milsp <sup>A</sup>	LC <sub>10</sub>	0.146	0.069	-	0.192
	LC <sub>50</sub>	0.242	0.182	-	0.334
	LC <sub>90</sub>	0.899	0.800	-	0.922

A= Ethanolic extract of leaves. B= Ethanolic extract of seeds. C= Hexane extract of leaves. D= Methanolic extract of leaves. E= Chloroform extract of leaves.

LC<sub>50</sub> 136 mg L<sup>-1</sup> and LC<sub>90</sub> 551 mg L<sup>-1</sup> (Prophiro et al. 2012, Trindade et al. 2013).

The second major toxicity was obtained in ethanol extract of *P. hispidum* leaves. *Piper* has been described as effective insecticide. Studies with *P. aduncum* showed larvicidal activity of essential oil on *A. aegypti* (Oliveira et al. 2013).

The extracts of leaves and roots of *P. aduncum* and extracts of leaves, fruits and branches of *P. tuberculatum* at 0.5 g L<sup>-1</sup> caused total mortality in *A. aegypti* larvae (Pohl et al. 2004). The essential oils of *P. gaudichaudianum*, *P. permucronatum*, *P. humaytanum* and *P. hostmanianum* against *A. aegypti* larvae were analyzed. The most active oil was *P. permucronatum* LC<sub>50</sub> 0.36 mg mL<sup>-1</sup>,

followed by *P. hostmanianum*  $LC_{50}$  0.54 mg mL<sup>-1</sup> (Morais et al. 2007).

According to Misni et al. (2008), the essential oil of *P. aduncum* acts as an excellent repellent for *A. aegypti*. Subsequent studies showed that the essential oil at 8 and 10% led to significant mortality higher for *A. aegypti* (80%) than for *A. albopictus* (71.6%) (Misni et al. 2011).

The essential oil of *P. marginatum* inflorescences did not affect the oviposition when at concentration of 0.05 mg mL<sup>-1</sup>, but was effective in mortality of *A. aegypti* larvae at  $LC_{10}$  and  $LC_{50}$  of 0.0138 and 0.02 mg L<sup>-1</sup>, respectively (Autran et al. 2009). Sousa et al. (2008) reported low toxicity when analyzing the action of *Piper* species on *A. aegypti* larvae.

The *grandisin lignan* isolated from *P. solmsianum* caused larval mortality at  $LC_{50}$  150 mg mL<sup>-1</sup>. Histological analyzes reveal that the larvae had changes in the digestive tract, in the anterior and middle intestine with a tissue disorganization followed by death (Leite et al. 2012).

Other authors analyzed the essential oils of *P. aduncum* and *P. hispidinervum* on *Tenebrio molitor* (Fazolin et al. 2007), *Piper aduncum* and *Piper hispidinervum* on *Sitophilus zeamais* (Estrela et al. 2006), and *P. aduncum* on *Ceratomyia tingomarianus* (Fazolin et al. 2005) reporting high toxicity. High insecticidal potential was attributed to *P. tuberculatum* extracts on larval stage of *Spodoptera frugiperda* (Castro 2007). Subsequently, Santos et al. (2010) describe the insecticidal activity of *P. hispidum* leaf extract and larvicidal potential on *Hypothenemus hampei* control.

According to the third  $LC_{50}$ , the most toxic extract was obtained from *S. variable* (Table I).

The aqueous extracts of *Solanum villosum* (Solanaceae) applied against *Stegomyia aegypti* (Culicidae) larvae caused mortality rates within 72 hours of exposure (Chowdhury et al. 2008).

*A. aegypti* larvae were subjected to *Nicotiana tabacum* (Solanaceae) extract.  $LC_{50}$  showed 0.45%

and 0.12%, and  $LC_{90}$  0.98% and 0.25%, respectively (Quirino 2010).

The larvicidal action on *A. aegypti* may be related to its antioxidant activity, causing inhibition of esterase, glutathione transferases or monooxygenases. This action was cited by Guirado et al. (2009) as one of the defense mechanisms of vectors and a common condition observed in resistant populations found in the national territory.

Preliminary phytochemical analysis of *Capsicum frutescens* var. *longum* showed high content of tannins, alkaloids, steroids and glycosides present in leaves and fruits (Vinayaka et al. 2010). They may be used as blockers of enzyme action since one of the mechanisms for larval mortality is related to the metabolism of esterases and other monooxygenase. Gupta et al. (2011) evaluated the larvicidal potential of seed  $\alpha$ -amylase inhibitor of *Macrotyloma uniflorum* in larvae, pupae and adults of *A. aegypti* and found adulticidal and larvicidal effect at a concentration of 0.2 mg mL<sup>-1</sup>.

To analyze the larvicidal potential of *Cestrum nocturnum* extract, Jawale et al. (2010) classified as active with 100% larvae mortality in 24 hours, setting  $LC_{100}$  12 mg L<sup>-1</sup> and  $LC_{50}$  6 mg L<sup>-1</sup>. In accordance with the results obtained for the extracts of *Plumbago zeylanica* and *C. nocturnum*, the presence of bioactive phytochemicals influenced life cycle of *A. aegypti* by inhibiting the development of pupae and adult emergence (Patil et al. 2011).

The extract of *T. umifolia* leaves in this study was the only one with no reports of insecticidal activity. The genus *Turnera* (Turneraceae), known as *chanana*, has distribution in Brazil and South America. Santos et al. (2010) analyzed of the extract of *T. ulmifolia* leaves and observed the molluscicidal activity against *Biomphalaria glabrata*, and cytotoxicity with *Artemia salina*. The species has also been effective in controlling infectious forms of *Trypanosoma cruzi* and *Leishmania* (Santos et al. 2012).

Reports from Nazar et al. (2009) and Dhanasekaran et al. (2013) describe the larvicidal and ovicidal potential and the repellent in ethanol extract of *S. hispida* against *Anopheles stephensi*, *A. aegypti* and *Culex tritaeniorhynchus*. The mortality of *A. stephensi* occurred at  $LC_{50}$  89.45 mg L<sup>-1</sup> and 100% repellency against female adult mosquitoes. Over 75% mortality was obtained from ethanolic extract of *Spermacoce verticillata* at concentration of 250 mg L<sup>-1</sup> on the larvae of *A. aegypti* (Souza et al. 2013).

The data obtained in this study from larvicidal activity and literature information enabled the characterization of the species potential. The family(ies) evaluated proved its potential compared to the literature. However, it is recommended to continue the monitoring studies of sub-lethal dosages and fractionation of greater efficiency extracts for identification of main active principles which can be used as efficiency markers for other species.

### CONCLUSIONS

This study shows the insecticide potential in plants found in Mato Grosso do Sul, Brazil. Forty-eight botanical species were analyzed and showed potential insecticide of *O. arborea*, *S. latifolia*, *S. variable*, *P. hispidum*, *P. aduncum* and *T. umifolia* in order of efficiency for causing toxicity at lower concentrations.

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