Anais da Academia Brasileira de Ciências (2017) 89(2): 895-906
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
http://dx.doi.org/10.1590/0001-3765201720150017
www.scielo.br/aabc

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

KARLA R. DE ANDRADE PORTO[1], PRISCILLA R. MOTTI[1], MAMI YANO[2], ANTONIA R. ROEL[1], CLAUDIA A.L. CARDOSO[4] AND ROSEMARY MATIAS[3]

[1]Universidade Católica Dom Bosco/UCDB, Av. Tamandaré, 6000, 79117-900 Campo Grande, MS, Brazil
[2]Faculdade Estácio de Sá de Campo Grande, Mato Grosso do Sul, R.Venâncio Borges do Nascimento, 377, 79050-700 Campo Grande, MS, Brazil
[3]Universidade Estadual de Mato Grosso do Sul/UEMS, Rodovia Itahum, Km 12, 351, 79804-970 Dourados, MS, Brazil
[4]Universidade Anhanguera - Uniderp, Av. Alexandre Herculano, 1400, 79037-280 Campo Grande, MS, Brazil

Manuscript received on January 9, 2015; accepted for publication on October 10, 2016

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^{-1}; 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_{50} for the most active of the extracts selected were ethanol extract of *Ormosea arborea* (0.111 mg mL^{-1}) seeds and ethanol extracts of leaves such as *Piper hispidum* (0.169 mg mL^{-1}), *Solanum variabile* (0.188 mg mL^{-1}), *O. arborea* (0.238 mg mL^{-1}), *Turnera umifolia* (0.242 mg mL^{-1}) and *Piper hispidum* (0.567 mg mL^{-1}). For plant fractions, the most active were chloroform (0.192 mg mL^{-1}) and hexane (0.342 mg mL^{-1}) *P. aduncum* leaves, hexane fraction (0.415 mg mL^{-1}) and methanol extract (0.625 mg mL^{-1}) of *Spermacocea 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

Correspondence to: Rosemary Matias
E-mail: rosematiasc@gmail.com

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 *Aede*s, 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 cittratus* (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* (Lamark) 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; *Sebastiana hispida* (Mart.) Pax; *Solanum variabile* Mart.; *Spermacocea verticilata* L.; *Spermacocea*

grisebachii L.; *Spermacocea 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 brasiliana* 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 ± 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^{-1} 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^{-1}. 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^{-1} in quadruplicate. The test results were checked after 24 hours of exposure.

STATISTICAL ANALYSIS

For the analysis of toxicity testing (LC_{10}, LC_{50} and LC_{90}), parametric regression method Probit (Mclaughlin 1991) was performed using Leoraâ software (POLO 9735947870655352).

RESULTS AND DISCUSSION

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

The extracts of *S. grisebacei, B. dracunculifolia* and *G. americana s*howed larvicidal activity capable of causing death in 30% of the population at concentration of 0.5 mg mL^{-1}. However, these extracts did not result in mortality at lower concentrations and hindered the calculation of LC_{50}.

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^{-1}.

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

TABLE I (continuation)

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

TABLE I (continuation)

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

TABLE I (continuation)

Species	Popular name	Plant organ	Extract (Ext.)/ Fraction (Fr.)	Death Percentage
Sapindaceae**(22)**				
Paullinia grandiflora St. Hill	*Timbó*	Leaves	Methanolic ext.	-
		Twig		-
		Seeds		-
Sapotaceae **(23)**				
Pouteria ramiflora (Mart.) Radlk	*Leitero preto, abiu*	Leaves	Ethanolic ext.	-
Solanaceae **(24)**				
Solanum variabile Mart.	*Jurubeba*	Leaves	Ethanolic ext.	100
Sterculiaceae **(25)**				
Guazuma ulmifolia Lamarck	Chico magro	Leaves	Ethanolic ext.	-
		Twig	Ethanolic ext.	-
		Leaves	Aqueous fr.	-
Sterculia apetala (Jacq.) H.Krast	*Mandovi, Amendoim-de-bugre*	Leaves	Methanolic ext.	-
Turneracea **(26)**				
Turnera ulmifolia L.	Erva damiana	Leaves	Ethanolic ext.	100
Verbenaceae **(27)**				
Stachytarpheta cayennensis Rich. Vahl	Gervão	Leaves	Ethanolic ext.	-
		Twig	Ethanolic 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^{-1} (Table I) and lethal concentrations (LC) at lower dilutions (Table II).

The ethanolic extract of *O. arborea* seeds (LC_{50} 0.111 mg mL^{-1}) was the most toxic showing high mortality at lower concentrations, followed by ethanolic extracts of *P. hispidum* (0.169 mg mL^{-1}), *S. variabile* (0.188 mg mL^{-1}), *O. arborea* (0.238 mg mL^{-1}), *T. umifolia* (0.242 mg.mL^{-1}) and *P. hispidum* (0.567 mg mL^{-1}) leaves. The most active fractions were chloroform (0.192 mg mL^{-1}) and hexane (0.342 mg mL^{-1}) of *P. aduncum* leaves; and hexane fraction (0.415 mg mL^{-1}) and methanol extract (0.625 mg mL^{-1}) 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_{50} showed values of 47 mg L^{-1} and LC_{90} 91 mg L^{-1}. For *C. guianensis,* the values were

TABLE II
Lethal Concentration (LC) in mg mL^{-1} for the different extracts of *Aedes aegypti* larvae.

Plant species	Lethal Concentration	Average value in correlation 95% (mg mL^{-1})	Range limit in correlation 95% (mg mL^{-1})		
Ormosea arborea Vell[A]	LC_{10}	0.164	0.133	-	0.185
	LC_{50}	0.238	0.216	-	0.266
	LC_{90}	0.347	0.307	-	0.429
Ormosea arborea Vell[B]	LC_{10}	0.063	0.050	-	0.073
	LC_{50}	0.111	0.098	-	0.124
	LC_{90}	0.194	0.168	-	0.239
Spermacoceae latifolia L.[C]	LC_{10}	0.191	0.125	-	0.245
	LC_{50}	0.415	0.341	-	0.512
	LC_{90}	0.901	0.690	-	1.441
Spermacoceae latifolia L.[D]	LC_{10}	0.125	0.118	-	0.148
	LC_{50}	0.625	0,618	-	0.653
	LC_{90}	1.122	1.178	-	1.153
Solanum variabile Mart.[A]	LC_{10}	0.097	0.062	-	0.124
	LC_{50}	0.188	0.153	-	0.232
	LC_{90}	0.284	0.249	-	0.581
Piper aduncum L.[C]	LC_{10}	0.122	0.118	-	0.190
	LC_{50}	0.342	0.206	-	0.401
	LC_{90}	0.473	0.414	-	0.670
Piper aduncum L.[E]	LC_{10}	0.034	0.035	-	0.042
	LC_{50}	0.192	0.188	-	0.195
	LC_{90}	0.346	0.340	-	0.350
Piper hispidum Sw.[A]	LC_{10}	0.060	0.477	-	0.721
	LC_{50}	0.169	0.169	-	0.189
	LC_{90}	0.474	0.403	-	0.582
Piper hispidum Sw.[E]	LC_{10}	0.320	0.264	-	0.366
	LC_{50}	0.567	0.501	-	0.665
	LC_{90}	1.003	0.818	-	1.410
Turnera ulmifolia Milsp[A]	LC_{10}	0.146	0.069	-	0.192
	LC_{50}	0.242	0.182	-	0.334
	LC_{90}	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_{50} 136 mg L^{-1} and LC_{90} 551 mg L^{-1} (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^{-1} caused total mortality in *A. aegypti* larvae (Pohlit 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_{50} 0.36 mg mL^{-1},

followed by *P. hostmanianum* LC_{50} 0.54 mg mL^{-1} (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^{-1}, but was effective in mortality of *A. aegypti* larvae at LC_{10} and LC_{50} of 0.0138 and 0.02 mg L^{-1}, 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^{-1}. 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 hispodinervum* on *Sitophilus zeamais* (Estrela et al. 2006), and *P. aduncum* on *Cerotoma tingomarianus* (Fazolin et al. 2005) reporting high toxicity. High insecticidal potential was attributed to *P. tuberculatum* extracts on larval stage of *Spodoptera fru*giperda (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. variabile* (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 α-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^{-1}.

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^{-1} and LC_{50} 6 mg L^{-1}. 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^{-1} and 100% repellency against female adult mosquitoes. Over 75% mortality was obtained from ethanolic extract of *Spermacocea verticillata* at concentration of 250 mg L^{-1} 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. variabile, P. hispidum, P. aduncum* and *T. umifolia* in order of efficiency for causing toxicity at lower concentrations.

ACKNOWLEDGMENTS

The Ministério de Ciência e Tecnologia (MCT), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU), Centro de Pesquisa do Pantanal (CPP), Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT), Universidade Anhanguera – Uniderp and Universidade Católica Dom Bosco. The authors are grateful to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for providing the research grant (PQ2).

REFERENCES

AUTRAN ES, NEVES IA, SILVA CSB, SANTOS GKN, CAMARA CAG AND NAVARRO DMAF. 2009. Chemical composition, oviposition deterrent and larvicidal activities against *Aedes aegypti* of essential oils from *Piper marginatum* Jacq. (Piperaceae). Bioresour Technol 100: 2284-2288.

BARATA EAMF, COSTA AIP, CHIARAVALLOTI FN, GLASSER CM, BARATA JMS AND NATAL D. 2001. População de *Aedes aegypti* (L.) em área endêmica de dengue, Sudeste do Brasil. Rev Saúde Publ 35: 237-242.

CASTRO MJP. 2007. Potencial inseticida de extratos de *Piper tuberculatum* JACQ. (Piperaceae) sobre a fase larval de *Spodoptera frugiperda* (J.E. Smith). Dissertação de mestrado, Mestrado em Agronomia, Universidade Federal do Piauí, 56 p. (Unpublished).

CAVALHEIRO MG, FARIAS DF, FERNANDES GS, NUNES EP, CAVALCANTI FS, VASCONCELOS IMV, MELO VMM AND CARVALHO AFU. 2009. Atividades biológicas e enzimáticas do extrato aquoso de sementes de *Caesalpinia férrea* Mart., Leguminosae. Braz J Pharmacog 19: 586-591.

CHOWDHURY N, GHOSH A AND CHANDRAG. 2008. Mosquito larvicidal activities of *Solanum villosum*berry extract against the dengue vector *Stegomyia aegypti.* BMC Complement Altern Med 8: 1-8.

DHANASEKARAN S, KRISHNAPPA K, ANANDAN A AND ELUMALAI K. 2013. Larvicidal, ovicidal and repellent activity of selected indigenous medicinal plants against malarial vector *Anopheles stephensi* (Liston.), dengue vector *Aedes aegypti* (Linn.) and *Japanese encephalitis* vector, *Culex tritaeniorynchus* (Giles.) (Diptera: Culicidae). J Agri Technol 9: 29-47.

ESTRELA JLV, FAZOLIN M, CATANI V, ALÉCIO MR AND LIMA MS. 2006. Toxicidade de óleos essenciais de *Piper aduncum* e *Piper hispodinervum* em *Sitophilus zeamais*. Pesq. Agropec Bras 41: 217-222.

FAZOLIN M, ESTRELA JLV, CATANI V, ALÉCIO MR AND LIMA MS. 2007. Propriedade inseticida dos óleos essenciais de *Piper hispidinervum* C. DC.: *Piper aduncum* L. e *Tanaecium noctornum* (Barb. Rodr.) Bur. & K. Shun sobre *Tenebrio molitor* L. 1758. Ciênc Agrotecnica 31: 113-120.

FAZOLIN M, ESTRELA JLV, CATANI V, LIMA MS AND ALÉCIO MR. 2005. Toxicidade do óleo de *Piper aduncum* L. a adultos de *Cerotoma tingomarianus* Bechyné (Coleoptera: Chrysomelidae). Rev Neotrop Entomol 34: 485-489.

FURTADO RF, LIMA MGA, ANDRADE NETO M, BEZERRA JNS AND SILVA MGV. 2005. Atividade larvicida de óleos essenciais contra *Aedes aegypti* L. (Diptera: Culicidae). Rev Neotrop Entomol 34: 843-847.

GARCEZ WS, GARCEZ FR, SILVA LMGE AND SARMENTO UC. 2013. Substâncias de Origem Vegetal com Atividade Larvicida Contra *Aedes aegypti.* Rev Virtual Quím 5: 363-393.

GOMES AC, SILVA NN, BERNAL RTI, LEANDRO AS, CAMARGO NJ, SILVA AM, FERREIRA AC, OGURA LC, OLIVEIRA SJ AND MOURA SM. 2007. Especificidade da armadilha *Adultrap* para capturar fêmeas de *Aedes aegypti* (Diptera: Culicidae). Rev Soc Bras Med Trop 40: 216-219.

GOVINDARAJAN M. 2009. Bioefficacy of *Cassia fistula* Linn. (Leguminosae) leaf extract against chikungunya vector, *Aedes aegypti* (Diptera: Culicidae). Eur Rev Med Pharmacol Sci 13: 99-103.

GUIRADO MM AND BICUDO HEMC. 2009. Alguns aspectos do controle populacional e da resistência a inseticidas em *Aedes aegypti* (Diptera, Culicidae). Bepa 6: 5-14.

GUPTA L, DESHPANDE S, TARE V AND SABHARWAL S. 2011. Larvicidal activity of the α-amylase inhibitor from the seeds of *Macrotyloma uniflorum* (Leguminosae) against *Aedes aegypt* (Diptera: Culicidae). In J Tro Insect Sci 31: 69-74.

HALSTEAD SB. 2007. Dengue. Lancet 370: 1644-1652.

JAWALE C, KIRDAK R AND DAMA L. 2010. Larvicidal activity of *Cestrum nocturnum* on *Aedes aegypti*. Bangladesh J Pharmacol 5: 39-40.

LEITE ACCF, KATO MJ, SOARES ROA, GUIMARÃES AE, SANTOS-MALLET J AND CABRAL MMO. 2012. Grandisin caused morphological changes larval and toxicity on *Aedes aegypti*. Braz J Pharmacog 22: 517-521.

LISTA DE ESPÉCIES DA FLORA DO BRASIL. 2013. Disponivel: http://floradobrasil.jbrj.gov.br. Access: April 2013.

MACIEL IJ, SIQUEIRA JÚNIOR JB AND MARTELLI CMT. 2008. Epidemiologia e desafios no controle do dengue. Rev Patol Trop 37: 111-130.

MCLAUGHLIN, JL, CHANG C AND SMITH D.I. 1991. Bench-top bioassays for the discovery of bioactive natural products: an update. In: Atta-Ur-Rahman (Ed), Studies in Natural Products Chemistry. Amsterdam: Elsevier Science Publishers B.V 9, p. 383-409.

MELO-SANTOS MAV ET AL. 2010. Resistance to the organophosphate temephos: Mechanisms, evolution and reversion in an *Aedes aegypti* laboratory strain from Brazil. Acta Tropica 113: 180-189.

MISNI N, OTHMAN H AND SULAIMAN S. 2011. The effect of *Piper aduncum* Linn. (Family: Piperaceae) essential oil as aerosol spray against *Aedes aegypti* (L.) and *Aedes albopictus* Skuse. Trop Biomed 28: 249-258.

MISNI N, SULAIMAN NS AND OTHMAN H. 2008. The Repellent Activity of *Piper aduncum* Linn (Family: Piperaceae) Essential Oil against *Aedes aegypti* Using Human Volunteers. J Trop Med Parasitol 31: 63-69.

MIYAZAKI RD, RIBEIRO ALM, PIGNATTI MG, CAMPELO JUNIOR JH AND PIGNATI M. 2009. Monitoramento do mosquito *Aedes aegypti* (Linnaeus, 1762) (Diptera: Culicidae), por meio de ovitrampas no Campus da Universidade Federal de Mato Grosso, Cuiabá, Estado de Matogrosso. Rev Soc Bra Med Trop 42: 392-397.

MORAIS SM, FACUNDO VA, BERTINI LM, CAVALCANTI ESB, ANJOS JÚNIOR JF, FERREIRA AS, BRITO ES AND SOUZA NETO MA. 2007. Chemical composition and larvicidal activity of essential oils from *Piper* species. Biochem Syst Ecol 35: 670-675.

NAZAR SR, WILLIAMS GP, ALI MS AND SUGANTHI P. 2009. Screening of Indian Coastal Plant Extracts for Larvicidal Activity of *Culex quinquefasciatus.* Indian J Chem Techn 2: 24-27.

OLIVEIRA ÉCL, PONTES ERJC, CUNHA RV, FRÓES ÍB AND NASCIMENTO D. 2009. Alterações hematológicas em pacientes com dengue. Rev Soc Bras Med Trop 42: 682-685.

OLIVEIRA FILHO EC. 2008. Avaliação da Periculosidade Ambiental de Bioinseticidas como uma Nova Perspectiva para a Ecotoxicologia no Brasil. J Braz Soc Ecotoxicol 3: 1-7.

OLIVEIRA MSC, MORAIS SM, MAGALHÃES DV, BATISTA WP, VIEIRA EGP, CRAVEIRO AA, MANEZES JESA, CARVALHO AFU AND LIMA GPG. 2011. Antioxidant, larvicidal and antiacetylcholinesterase activities of cashew nut shell liquid constituents. Acta Trop 117: 165-170.

OLIVEIRA GL, CARDOSO SK, LARA JÚNIOR CR, VIEIRA TM, GUIMARÃES EF, FIGUEIREDO LS, MARTINS ER, MOREIRA DL AND KAPLAN MAC.2013. Chemical study and larvicidal activity against *Aedes aegypti* of essential oil of *Piper aduncum* L. (Piperaceae). An Acad Bras Cienc 85: 1227-1234.

PATIL CD, PATIL SV, SALUNKE BK AND SALUNKHE RB. 2011. Bioeficácia de *Plumbago zeylanica* (Plumbaginaceae) e *Cestrum nocturnum* (Solanaceae) extratos de plantas contra *Aedes aegypti* (Diptera: Culicide) e não-alvo de peixes *Poecilia reticulata***.** Parasitol Res 108: 1253-1263.

POHLIT AM ET AL. 2004. Screening of plants found in the State of Amazonas, Brazil for larvicidal activity against *Aedes aegypti* larvae. Acta Amaz 34: 97-105.

PONTES RJS, REGAZZI ACF, LIMA JWO AND KERR-PONTES LRS. 2005. Efeito residual de apresentações

comerciais dos larvicidas temefos e *Bacillus thuringiensis* var. *Israelensis* sobre larvas de *Aedes aegypti* em recipientes com renovação de água. Rev Soc Bras Med Trop 38: 316-321.

PROPHIRO JS, SILVA MAN, KANIS LA, ROCHA LCBP, DUQUE-LUNA JE AND SILVA OS. 2012. First report on susceptibility of wild *Aedes aegypti* (Diptera: Culicidae) using *Carapa guianensis* (Meliaceae) and *Copaifera* sp. (Leguminosae). Parasitol Res 110: 699-705.

QUIRINO TF. 2010. Avaliação do potencial inseticida de solução de *Nicotiana tabacum* L. (Solanacea) para o controle de *Aedes aegypti* (L.) (Diptera:Culicidae). Trabalho de Conclusão de Curso (Graduação em Ciências Biológicas) - Universidade Estadual da Paraíba, Campina Grande, 54p. (Unpublished).

RODRÍGUEZ MM, BIEET JA AND FERNÁNDEZ D. 2007. Levels of insecticide resistance and resistance mechanisms in *Aedes aegypti* from some latin american countries. J Am Mosq Control Assoc 2: 420-429.

SANTOS AP, ZATTA DT, MORAES WF, BARA MTF, FERRI PH, SILVA MRR AND PAULA JR. 2010. Composição química, atividade antimicrobiana do óleo essencial e ocorrência de esteróides nas folhas de *Pterodon emarginatus* Vogel, Fabaceae. Braz J Pharmacog 20: 891-896.

SANTOS KKA ET AL. 2012. Avaliação da atividade anti-*Trypanosoma* e anti-*Leishmania* de *Mentha arvensis*e *Turnera ulmifolia.* B Latinoam Caribe Pl 11: 147-153.

SHAALAN EAS, CANYON DV, YOUNES MWF, WAHAB HA AND MANSOUR HA. 2005. Efects of sub - lethal concentrations of synthetic insecticides and *Callitris glaucophylla* extracts on the development of *Aedes aegypti*. J Vector Ecol 30: 295-298.

SANTOS VT, CANTO-DOROW TS AND EISINGER SM. 2010. Composição florística do componente herbáceo do Jardim Botânico da UFSM, Santa Maria, Rio Grande do Sul. Ciênc Nat 32: 61-82.

SOUSA PJC, BARROS CAL, ROCHA JCS, LIRA DS, MONTEIRO GM AND MAIA JGS. 2008. Avaliação toxicológica do óleo essencial de *Piper aduncum* L. Rev Bras Farmacog 18: 217-221.

SOUZA RKD, ALCANTARA MMAC AND PESSOA DA SILVA MA. 2013. Aspectos etnobotânicos, fitoquímicos e farmacológicos de espécies de Rubiaceaeno Brasil. Rev Cub Plant Med 18: 140-156.

TEIXEIRA MG, COSTA MC, BARRETO F AND BARRETO ML. 2009. Dengue: twenty-five years since reemergence in Brazil. Cad. Saúde Pública 25: S7-S18.

TRINDADE FTT, STABELI RG, PEREIRA AA, FACUNDO VA AND ALMEIDA E SILVA, A. 2013. *Copaifera multijuga* ethanolic extracts, oilresin, and its derivatives display larvicidal activity against *Anopheles darling* and *Aedes aegypti* (Diptera: Culicidae). Braz. J. Pharmacog 23: 464-470.

VILELA RAG, MALAGOLI ME AND MORRONE LC. 2010. Gerenciamento participativo em saúde do trabalhador uma experiência na atividade de controle de vetores. Saúde Soc 19: 969-980.

VINAYAKA KS, PRASHITH KEKUDA TR, NANDINI KC, RAKSHITHA MN, RAMYA M, SHRUTHI J, NAGASHREE GR AND ANITHA B. 2010. Potent insecticidal activity of fruits and leaves of *Capsicum frutescens* (L.) var. *longa* (Solanaceae). Pharm. Lett 2: 172-176.