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BIOLOGICAL ACTIVITY OF *MUSA ACUMINATA* (MUSACEAE) EXTRACTS AGAINST THE MOSQUITO VECTOR; *CULEX PIPIENS* L. (DIPTERA: CULICIDAE)

By

AHMED S. BREAM, AHMED Z. I. SHEHATA* AND MOHAMED S. M. ZAKI

Department of Zoology, Faculty of Science, Al-Azhar University, Nasr City, Cairo, Egypt (*Correspondence:ahmedzeinhom00@gmail.com)

Abstract

The present study evaluated the activity of ethanol 70%, acetone, chloroform and petroleum ether extracts of *Musa acuminata* leaves against the 3rd instar larvae of the mosquito vector, *Culex pipiens* (Diptera: Culicidae) which act as a vector of many diseases in Egypt. In addition, the repellent activity of the tested extracts against *C. pipiens* adults was examined. The obtained results revealed that, all tested plant extracts showed a larvicidal activity against the 3rd instar larvae of *C. pipiens*; however, the petroleum ether extract was more effective with LC_{50} 571.8ppm than chloroform, acetone and ethanolic extracts, where the LC_{50} values recorded 1567.3, 1158.3 and 1034.1ppm; respectively. On the other hand, all tested extracts evoked a variable degree of repellent activity against *C. pipiens* starved females. Also, petroleum ether extract was the most effective extract that exhibited high repellent action as compared with the chloroform, acetone and ethanolic extracts. These results demonstrated that ethanolic, acetone, chloroform and petroleum ether extracts of *M. acuminata* leaves serve as pest control agents, even in their crude form. These results provide an opportunity to develop alternatives to costly organic pesticides with some available cheap plants which are usually safe to the environment and to non-target organisms.

Keys words: Larvicidal, Repellent, *C. pipiens*, Plant extract, *Musa acuminata*.

Introduction

Mosquitoes transmit several public health diseases, such as malaria, filariasis and dengue causing millions of deaths every year (Vatandoost, 2001). In Egypt, *Culex pipiens* has a wide distribution and is the main vector of Rift Valley fever virus (Meagan *et al*, 1980; Darwish and Hoogastraal, 1981), *Wuchereria bancrofti* (Khalil *et al*, 1930; Gad *et al*, 1996) and Western Nile virus (El-Bahnasawy *et al*, 2013). Mmosquitoes immature stages are attractive targets for pesticides as they breed in water and thus easy to deal with them (Johnson and Singh, 2017).

Although chemical pesticides are dealt with *C. pipiens* control for many decades, these chemicals have negative effects on human health and the environment, as well as induce resistance in many mosquito species (Hemingway and Ranson, 2000). Plants are rich source of alternative agents for mosquito's control, because they possess bioactive chemicals, which act as insecticides, oviposition deterrents, repellents, growth inhibitors, juvenile hormone mimics, moulting hormones, as well as attractants (Murugan *et al*, 1996). Also, botanical pesticides offer an advantage over synthetic ones as they are less toxic, less prone to develop resistance and more easily degradable.

Materials and Methods

Tested mosquitoes: Laboratory of Medical Entomology in the Animal House, Faculty of Science, Al-Azhar University has cultured *Culex pipiens* mosquito colonies for several generations under controlled temperature and humidity using the standard procedures (Kasap and Demirhan, 1992).

Collection and extraction of plant materials: *Musa acuminata* was collected in the month of March 2017 from Sharkia Governorate, away from sun rays were left to dry at room temperature (25-30ºC) for 5 to 10 days and pulverized to powder separately in a hammer mill. The extraction was performed using ethanol 70%, acetone, chloroform and petroleum ether solvents. One hundred grams of *M. acuminata* leaves powder for each solvent were extracted separately and filtered five times using 300ml

of ethanol, acetone, chloroform and petroleum ether at room temperature. After 24 h., the supernatants were decanted, filtrated through Whatman filter paper (No. 5) and dried in a rotary evaporator at 40 ºC for 2-3 hours for methanol and 40-60 minutes for other solvents. Dry extracts were weighed and kept at -4ºC till using for experiments.

Larvicidal activity: Tested material of the ethanolic extracts was dissolved in 0.1ml of ethanol 70%, while those of acetone, chloroform and petroleum ether extracts were dissolved in 2 drops of $Tween_{80}$ as emulsifier to facilitate the dissolving oils of tested material in water. Different concentrations of each extract were prepared to detect mortalities.

All tested materials were performed in 250ml. of dechlorinated tap water contained in 300ml plastic cups. Then, 25 third instar larvae were put immediately into plastic cups contained different concentrations of extracts. Three replicates were usually used for each concentration. All plastic cups were incubated under controlled conditions (27±2°C, RH 70±10% and 12-12 light-dark regime). Control larvae received only 0.1ml of ethanol 70% or 2drop of $Tween_{80}$ in 250ml water. Mortality was recorded every daily (El-Sheikh *et al*, 2012).

Larval mortality was indicated by a failure to respond to mechanical stimulation (Williams *et al*, 1986) and estimated using the following equation (Briggs, 1960): larval mortality% = A-B/A×100 (where: A = No. of tested larvae, B = No. of tested pupa).

Pupal mortality percent was estimated using the following equation: Pupal mortality % = A-B/A×100 (where: A = No. of produced pupae, B = No. of emerged adults). Emerging males and females were counted using the following equation: Adult emergence % =A/B×100 (where: A = No. of emerged adults, B = No. of tested pupae). Growth index was estimated by using the equation: Growth index = a/b (where: A= % of adult emerged and B= mean development in days)

Repellent activity: Standard cages were used (20×20×20cm) to test the repellent activity of *M. acuminata* extracts. Different weights from each extract were dissolved in 2ml (ethanol 70%, acetone, chloroform and petroleum ether with a drop of $Tween_{80}$ separately) to prepare different concentrations.

The concentration was directly applied onto 5×6cm of ventral surface of pigeon after feathers removal from abdomen to evaluate the repellency against *C. pipiens* compared with commercial available repellent DEET (N. N. diethyl-toulamide; Johnson Wax, Egypt) as a positive control agent. After 10 minutes, the treated pigeons were placed in the cages containing *C. pipiens* starved females (5-7d-old) for three hours. Control tests were carried out side by side with treatments using ethanol or water. Each test was repeated three times to get a mean value of repellent activity (El-Sheikh *et al*, 2012). After treatments, the number of fed and unfed females were calculated according to Abbott (1925): Repellency % = [%A-%B/ 100-% B]×100 (where: A = percent of unfed females in treatment and B = percent of unfed females in control.

Statistical analysis: Analysis of data was carried out (lentner *et al*, 1982). LC_{50} was calculated using multiple linear regressions (Finney, 1971).

Results

Larvicidal activity: Larval mortality values were increased linearly with increasing concentrations. The complete larval mortality (100.0%) was attained by ethanolic, acetone, chloroform & petroleum ether extracts at 3500, 3000, 2000 and 1000ppm and the lowest mortality percent (17.3, 28.0, 16.0 & 20.0%) caused by the lowest concentrations (500, 500, 500 & 300ppm), respectively.

The mean larval duration period was significantly ($P<0.05$) prolonged due to ethanolic, acetone and petroleum ether extracts at the higher concentrations as compared with control groups, in the same time. The chloroform extract induced a significant ($P<0.05$) shortage in the larval duration values with higher concentrations (1600, 1400, 1200 & 1000 ppm) recorded 5.2, 5.4, 5.7 &

5.8days, res- pectively, compared with 7.3 days for the Lethal effect of acetone, chloroform and petroleum ether extracts extended to the resulted pupae, as the pupal mortality recorded 36.1 & 15.2% at 2500 and 2000 ppm for acetone extract; 33.3, 32.8 & 5.5% at 1800, 1600 and 1400ppm for chloroform extract and 44.4, 24.5, 24.7, 21.7, 13.9, 16.8 and 16.6% at 900, 800, 700, 600, 500, 400. and 300ppm for petroleum ether extract, respectively compared with zero pupal mortality in control groups. Ethanolic and chloroform extracts of *M. acuminata* were not significant (P>0.05) affected the pupal duration, the time taken by pupae to reach adult stage.

Table 1: Effect of ethanolic extract from *M. acuminata* leaves on some biological aspects of *C. pipiens.*

Conc. ppm	Larval mort. (%)	Larval Period	Pupal Mort. (%)	Pupal Period	Adult Emergence (%)	Development Period	Growth Index
3500	100.0±0.0	---	---	---	---	---	---
3000	90.7±2.3	7.1±0.2^{d}	0.0±0.0	3.4±0.1^{a}	100.0±0.0	10.5±0.3^{c}	9.5
2500	78.7±4.6	6.7±0.3^{c}	0.0±0.0	2.8±0.2^{a}	100.0±0.0	9.5±0.4^{a}	10.5
2000	65.3±2.3	6.6±0.3^{c}	0.0±0.0	2.6±0.4^{a}	100.0±0.0	9.2±0.6^{a}	10.9
1500	48.0±6.9	6.5±0.3^{c}	0.0±0.0	2.5±0.2^{a}	100.0±0.0	9.0±0.5^{a}	11.1
1000	34.7±4.6	6.4±0.2^{b}	0.0±0.0	2.4±0.1^{a}	100.0±0.0	8.8±0.4^{a}	11.4
500	17.3±2.3	6.2±0.1^{a}	0.0±0.0	2.4±0.1^{a}	100.0±0.0	8.6±0.3^{a}	11.7
Control	2.7±2.3	5.6±0.2^{a}	0.0±0.0	2.8±0.5^{a}	100.0±0.0	8.4±0.7^{a}	11.9

No. of tested larvae = 25 per one replicate; Conc. = Concentration; ppm = particle per million; SD = standard deviation; mort. = mortality; a = non-significant (P>0.05); b = significant (P<0.05); c = highly significant (P<0.01); d = very highly significant (P<0.001). Means followed by the same letter are not significantly different.

Table 2: Effect of acetone extract from *M. acuminata* leaves on some biological aspects of *C. pipiens.*

Conc. ppm	Larval mort. (%)	Larval Period	Pupal Mort. (%)	Pupal Period	Adult Emergence (%)	Development Period	Growth Index
3000	100.0±0.0	---	---	---	---	---	---
2500	88.0±40.0	7.1±0.2^{d}	36.1±12.7	3.0±0.1^{c}	63.9±12.7	10.1±0.3^{c}	6.3
2000	76.0±40.0	6.4±0.3^{c}	15.2±14.3	2.9±0.2^{b}	84.8±14.3	9.3±0.5^{b}	9.1
1500	64.0±40.0	6.3±0.1^{b}	18.8±4.1	2.7±0.2^{a}	81.2±4.1	9.0±0.3^{a}	9.0
1000	45.3±4.6	6.0±0.2^{a}	0.0±0.0	2.5±0.2^{a}	100.0±0.0	8.5±0.4^{a}	11.8
500	28.0±4.0	5.9±0.1^{a}	0.0±0.0	2.3±0.1^{a}	100.0±0.0	8.2±0.2^{a}	12.2
Control	8.0±6.9	5.6±0.2^{a}	0.0±0.0	3.0±0.2^{a}	100.0±0.0	8.6±0.4^{a}	11.6

Table 3: Effect of chloroform extract from *M. acuminata* leaves on some biological aspects of *C. pipiens.*

Conc. ppm	Larval mort. (%)	Larval Period	Pupal Mort. (%)	Pupal Period	Adult Emergence (%)	Development Period	Growth Index
2000	100.0±0.0	---	---	---	---	---	---
1800	93.3±2.3	5.3±0.0	33.3±28.9	2.3±0.2^{a}	66.7±28.9	7.6±0.2^{b}	8.9
1600	84.0±4.0	5.2±1.0^{b}	32.8±7.5	2.4±0.2^{a}	50.5±22.4	7.6±1.2^{b}	6.6
1400	72.0±4.0	5.4±0.4^{b}	5.5±9.6	2.6±0.3^{a}	94.5±9.6	8.0±0.7^{b}	11.8
1200	62.7±2.3	5.7±0.4^{b}	0.0±0.0	2.6±0.3^{a}	100.0±0.0	8.3±0.7^{b}	12.5
1000	50.7±4.6	5.8±0.4^{b}	0.0±0.0	2.8±0.1^{a}	100.0±0.0	8.6±0.5^{a}	11.6
800	36.0±4.0	6.4±1.0^{a}	0.0±0.0	3.1±0.2^{a}	100.0±0.0	9.5±1.2^{a}	10.5
500	16.0±4.0	7.0±0.6^{a}	0.0±0.0	3.3±0.6^{a}	100.0±0.0	10.3±1.2^{a}	9.7
Control	5.3±4.6	7.3±1.2^{a}	0.0±0.0	2.0±0.1^{a}	100.0±0.0	9.3±1.3^{a}	10.8

Table 4: Effect of petroleum ether extract from *M. acuminata* leaves on some biological aspects of *C. pipiens.*

Conc. ppm	Larval mort. (%)	Larval Period	Pupal Mort. (%)	Pupal Period	Adult Emergence (%)	Development Period	Growth Index
1000	100.0±0.0	---	---	---	---	---	---
900	90.7±2.3	7.0±.0.0	44.4±9.6	4.0±0.0	55.5±9.6	11.0±0.0	5.0
800	80.0±6.9	6.7±0.1^{c}	24.5±4.3	3.5±0.2^{d}	75.5±4.3	10.2±0.3^{d}	7.4
700	60.0±8.0	6.0±0.6^{a}	24.7±11.2	3.2±0.1^{b}	75.3±11.2	9.2±0.7^{a}	8.2
600	50.7±6.1	6.3±0.1^{a}	21.7±5.31	3.0±0.1^{a}	78.3±5.3	9.3±0.1^{a}	8.4
500	41.3±8.3	6.1±0.1^{a}	13.9±8.2	2.9±0.2^{a}	86.0±8.1	9.0±0.2^{a}	9.6
400	30.7±12.2	6.07±0.1^{a}	16.8±7.3	2.8±0.0^{a}	83.3±7.2	8.9±0.1^{a}	9.4
300	20.0±10.6	6.03±0.6^{a}	16.6±2.1	2.6±0.1^{b}	83.3±2.1	8.6±0.7^{a}	9.7
Control	2.7±1.6	5.5±0.1^{a}	00.0	2.9±0.1^{a}	100.0±0.0	8.4±0.2^{a}	11.9

Table 4: Effect of petroleum ether extract from *M. acuminata* leaves on some biological aspects of *C. pipiens.*

Conc. ppm	Larval mort. (%)	Larval Period	Pupal Mort. (%)	Pupal Period	Adult Emergence (%)	Development Period	Growth Index
1000	100.0±0.0	---	---	---	---	---	---
900	90.7±2.3	7.0±.0.0	44.4±9.6	4.0±0.0	55.5±9.6	11.0±0.0	5.0
800	80.0±6.9	6.7±0.1[c]	24.5±4.3	3.5±0.2[d]	75.5±4.3	10.2±0.3[d]	7.4
700	60.0±8.0	6.0±0.6[a]	24.7±11.2	3.2±0.1[b]	75.3±11.2	9.2±0.7[a]	8.2
600	50.7±6.1	6.3±0.1[a]	21.7±5.31	3.0±0.1[a]	78.3±5.3	9.3±0.1[a]	8.4
500	41.3±8.3	6.1±0.1[a]	13.9±8.2	2.9±0.2[a]	86.0±8.1	9.0±0.2[a]	9.6
400	30.7±12.2	6.07±0.1[a]	16.8±7.3	2.8±0.0[a]	83.3±7.2	8.9±0.1[a]	9.4
300	20.0±10.6	6.03±0.6[a]	16.6±2.1	2.6±0.1[b]	83.3±2.1	8.6±0.7[a]	9.7
Control	2.7±1.6	5.5±0.1[a]	00.0	2.9±0.1[a]	100.0±0.0	8.4±0.2[a]	11.9

Table 5: Relative efficiency of tested *M. acuminata* leaves extracts against larvae of *C. pipiens*.

Extract	LC_{50} (ppm)	Slope (b)	R^2
Ethanol 70%	1567.3	0.0279	0.9923
Acetone	1158.3	0.0286	0.9892
Chloroform	1034.1	0.0564	0.9898
Petroleum ether	571.8	0.1173	0.9911

Table 6: Repellent activity of tested *M. acuminata* leaves extracts against *C. pipiens* starved females.

Extracts	Dose (mg/cm^2)	No. of tested females	Fed Females		Unfed Females		Repellency (%)
			No.	%	No.	%	
Ethanol 70%	3.33	49	12	24.5	37	75.5	74.5
	1.67	55	16	29.1	39	70.7	69.5
	0.83	67	22	32.8	45	67.2	65.9
Acetone	3.33	47	9	19.1	38	80.9	79.0
	1.67	51	14	27.5	37	72.5	69.8
	0.83	48	15	31.1	33	68.7	65.6
Chloroform	3.33	55	9	16.4	46	83.6	82.8
	1.67	41	10	24.4	31	75.6	74.5
	0.83	49	15	30.6	34	69.4	68.0
Pet. ether	3.33	63	6	9.5	57	90.5	90.0
	1.67	48	8	16.7	40	83.3	82.4
	0.83	52	11	21.2	41	78.8	77.6
DEET	1.8	58	0	0.0	58	100.0	100.0
Control	0.0	53	51	96.2	2	3.8	0.0

But, the pupal duration was significantly ($P<0.05$) shortened by acetone extract; 3.0 & 2.9days at 2500 and 2000ppm compared with 3.0days for control group (Tab. 2) and significantly ($P<0.05$) prolonged by petroleum ether extract; pupal duration was 3.5 & 3.2days at 800 and 700ppm, respectively, compared with 2.9days for control group.

The reduction in adult emergence percent was observed due to tested acetone, chloroform and petroleum ether extracts, petroleum ether extracts recorded 55.5, 75.5, 75.3, 78.3, 86.0, 83.3 & 83.3% adult emergence at 900, 800, 700, 600, 500, 400 and 300ppm, respectively, compared with complete adult emergence in the untreated group. Also, a retarded effect on growth of larvae, pupae and adult *C. pipiens* was induced by all extracts used especially with petroleum ether extract, which reduced growth index value from 11.9 in control group to 9.7 at lowest concentration (300ppm) and 8.2, 7.4, 5.0 at the highest concentrations (700, 800 & 900ppm), respectively (Tab. 4).

Thus, it was obvious that, the toxicity values of the tested ethanol 70%, acetone, chloroform and petroleum ether extracts of *M. acuminata* leaves based on LC_{50} values (Tab. 5; Fig. 1) could be arranged in a descending order as follows: Petroleum ether extract > Chloroform extract > Acetone extract > Ethanolic extract.

Repellent activity of tested plant extracts on *Culex pipiens* adults: The ethanolic, acetone, chloroform and petroleum ether extracts of *M. acuminata* leaves gave a variable degree of repellency. Potent repellency (90.0%) attained by petroleum ether extract

at 3.33mg/cm^2 through the 3h post treatment, the ethanolic extract evoked 74.5, 69.5 and 65.9% protection at 3.33, 1.67 & 0.83 mg/cm^2. Acetone and chloroform extracts exhibited 79.0, 69.8, 65.6 & 82.8, 74.5, 68.0% repellency action, respectively, within the 3h post treatment. In addition, 82.4 & 77.6% repellency achieved by petroleum ether extract at 1.67 and 0.83mg/cm^2, compared with 100.0% repellency for DEET at a dose of 1.8mg/cm^2 (Tab. 6).

Discussion

The vector control by synthetic pesticides faced a threat due to the development of resistance to chemical insecticides (Liu *et al,* 2006). Moreover, this is highly indicated in Egypt with the reemerged *Aedes aegypti* (Heikal *et al,* 2011; Shoukry *et al,* 2012) and the introduced dengue fever (El Bahnasawy *et al*, 2011a; Morsy, 2018) as well as introduction of *Anopheles* vector (El-Bahnasawy *et al*, 2011b) and the imported malignant malaria (El-Bahnasawy *et al*, 2010) Thus, there is an urgent need to develop new materials for controlling mosquitoes in an environmentally safe way. Plant extracts have been suggested as alternative sources for insect control, because some are selective, biodegrade to nontoxic products and have few effects on non-target organisms and the environment (Singh and Upadhyay, 1993; Isman, 2006; Pavela, 2007). *Musa acuminata*, belongs to Musaceae family is known to be eco-friendly and isn't toxic to vertebrates. Moreover, it is clearly proved that crude or partially purified plant extracts are less expensive and highly efficacious for the control of *Culex pipiens* rather than the purified compounds or extracts (Jang *et al,* 2002; Cavalcanti *et al,* 2004). The present results offered an opportunity for developing alternatives to rather expensive and environmentally hazardous organic insecticides.

In the present study, toxicity of *M. acuminata* extracts against 3rd instar larvae of *C. pipiens* was varied according to solvent used in extraction and concentration of the extract. The larval mortality percent was increased by increasing extract concentration for all plant extracts tested. Generally, the present results indicated that, the petroleum ether extract was more effective against 3rd instar larvae of *C. pipiens* than those of chloroform, acetone and ethanolic extracts. These results were in consistent with the previously mentioned suggestions of (Maurya *et al,* 2009). Several studies concerned with the effect of several medicinal plant extracts on different mosquito's species were performed by many authors worldwide (Abdel-Sattar *et al,* 2014. The effect of tested plant extracts on larval mortality of *C. pipiens* agreed with of Vahitha *et al*. (2002) for leaf extracts of *Pavonia zeylanica* and *Acacia ferruginea* on the late third instar larvae of *C. quinquefasciatus*, LC_{50} values recorded 2214.7 & 5362.6ppm. Prabakar and jebanesan, (2004) used extracts from five species of Cucurbitacious plants, *Momordica charantia, Trichosanthes anguina, Luffa acutangula, Benincasa cerifera* and *Citrullus vulgaris* against the late third larval age of *C. quinquefasciatus*. LC_{50} values after 24hr were 465.85, 567.81, 839.81, 1189.30 & 1636.04 ppm. Moreover, Nathan *et al.* (2005) reported that azadirachtin was most potent in all experiments against the malaria vector, *A. stephensi* L. and produced almost 100% larval mortality at 1ppm concentration. Coria *et al.* (2008) used extracts from *Melia azedarach* on *A. aegypti*, and Maurya *et al.* (2009) used petroleum ether extract from leaves of a widely grown medicinal plant, *Ocimum basilicum*, against *A. stephensi* and *C. quinquefasciatus* and reported that the petroleum ether extract from leaves of *O. basilicum* was most effective against the larvae of both mosquitoes than other extracts with LC_{50} of 8.29, 4.57; 87.68, 47.25ppm and LC_{90} values of 10.06, 6.06; 129.32, 65.58ppm against *A. stephensi* and *C. quinquefasciatus* reswpectively, after 24 & 48hr of treatment and Madhua *et al.* (2010) used *Curcuma aromatica* rhizomes extracts on *C. quinquefasciatus* larvae. The efficacy of petroleum ether extract seemed to be effective

with LC_{50} & LC_{90} values of 11.4 and 18.0 ppm. This went with Sakthivadivel *et al.* (2014) who found that aqueous fruit extract of *Wrightia tinctoria* exhibited highest larvicidal activity against *C. quinquefasciatus* followed by aqueous leaf extract with LC_{50} values of 0.17% and 0.09%; 0.21% & 0.11% after 24 and 48hr. Samuel *et al.* (2014) reported that *Ipomoea cairica* and *Ageratina adenophora* extracts were effective against third instar larvae of *C. quinquefasciatus* caused 77-100% mortality at 48hr. Also, Asiry *et al.* (2017) used ethanolic leaf extracts from four plants, *Citrullus colocynthis*, *Artemisia annua*, *Pergularia tomentosa* and *Rhanterium epapposum* selected from Hail region, northern Saudi Arabia, against the larval stages of *Ae. aegypti*. The ethanolic extracts of *R. epapposum* and *A. annua* were more toxic to the 4th instar larvae of *Ae. aegypti* compared to the other two plants. Nasir *et al.* (2017) used essential oils of some medicinal plants against *Ae. albopictus*, Ginger was more effective with lowest LC_{50} values after 8 & 16hr followed by peppermint, basil, Eucalyptus and Neem. Basil was efficacious after 24 and 48h.

In the present study, ethanolic and petroleum ether extracts extended the larval and pupal durations. Acetone extract shortened the pupal duration and chloroform extract shortened the larval duration. These results agreed with Jeyabalan *et al.* (2003) using methanol extract of *Pelargonium citrosa* leaf against *A. stephensi* larvae, Nathan *et al.* (2005) using *Azadirachta indica* extract against *A. stephensi* larvae, Nathan *et al.* (2006) using methanolic extracts of leaves and seeds from chinaberry tree, *Melia azedarach* against *A. stephensi* larvae, Sharma *et al.* (2006a; b) using petroleum ether extract of *Artemisia annua* against *A. stephensi* and *C. quinquefasciatus* larvae. Similar observation was reported by Coria *et al.* (2008) using ethanolic extract of *Melia azedarach* leaves on *Ae. aegypti* larvae and Juliene *et al.* (2009) using *Moringa oleifera* lectin against *Ae. aegypti* larvae.

In the present study, the decrease in the percentage of adult emergence of the mosquito vector, *C. pipiens* due to treatment with the tested plant extracts was similar to the results obtained previously by Assar and El- Sobky (2003) using water extracts of *Artimisia Monosperma* against *C. pipiens* larvae, El- Bokl (2003) using *Azadirachta indica* extract against *C. pipiens* larvae, Nathan *et al*. (2006) used methanolic extracts of leaves and seeds of *Melia azedarach* against *A. stephensi* larvae, Sharma *et al.*, (2006a; b) used petroleum ether extract of *Artemisia annua* against *A. stephensi* and *C. quinquefasciatus* larvae, Wiesman and Chapagain, (2006) used one fraction obtained from the silica gel column chromatography of the methanol extract against *Aedes aegypti* mosquito larvae. Also, Asiry *et al.* (2017) used ethanolic leaf extracts from four plants, *Citrullus colocynthis* (bitter apple), *Artemisia annua* (sweet wormwood), *Pergularia tomentosa* (Fattaka) and *Rhan-terium epapposum* (Arfaj) against the larval stages of *Ae. aegypti* and Nasir *et al.* (2017) used essential oils of some medicinal plants against *Ae. albopictus*.

In the present study, the growth index of *C. pipiens* was affected by the present plant extracts tested. It decreased as the concentration of the extract increased. Retardation in growth was induced by different solvents. Such results were in agreement with earlier studies using different plant extracts against some dipteran species by Jeyabalan *et al.*, (2003) using *Pelargonium citrosa* leaf extracts on *A. stephensi*, Nathan *et al*., (2006) using *Melia azedarach* on *A. stephensi*, Sharma *et al.*, (2006 b) sing *Artemisia annua* extract against *C. autnauetesctetus*, Bream *et al.* (2010) using *Echinochloa stagninum* extracts against *C. pipiens*, El-Sheikh *et al.* (2012) using methanolic extract of *Tribulus terrestris* L. (Zygophyllaceae) against the malarial vector, *A. arabiensis* and Fouda *et al.* (2017) using *L. camara* (leaves and stems) extracts against the house fly, *Musca domestica*.

In the present study, all doses of plant extracts used in the present study exhibited repellent activity against the starved female adults of *C. pipiens*. The repellent activity was solvent and dose dependent. The results indicate that, petroleum ether extraction of *M. acuminata* was more effective in exhibiting the repellent action against the mosquito tested as compared with chloroform, acetone and ethanolic extract. Many plant extracts and essential oils manifest repellent activity against different mosquito species and the present results were in accordance with such results obtained by Govere *et al*. (2000) using extracts of fever tea (*Lippia javanica*), rose geranium (*Pelargonium reniforme*) and lemon grass (*Cymbopogon excavatus*) against *A. arabiensis*, Kim *et al*. (2002) used ethanol extract of fruits from *Foeniculum vulgarea* against hungry *Aedes aegypti* females, Choi *et al*. (2002) tested the essential oils of *Eulcalyptus globulus*, *Lavender officinalis*, *Rosemarinus officinalis* and *Thymus vulgaris* against *C. pipiens*, Jeyabalan *et al.* (2003) using methanol extracts of *Pelargonium citrosa* against *A. stephensi*, Tuetun *et al*. (2004) using extracts of *Apium graveolens* seeds against *Ae. aegypti*, Yang *et al*. (2004) using methanol extracts from twenty- three aromatic medicinal plant species against *Ae. aegypti* female, Prajapati *et al*. (2005) using essential oils extracted from ten medicinal plants against *A. stephensi* and *C. quinquefasciatus*, Choochote *et al.* (2007) using repellent activity of selected essential oils from ten plant species against *Ae. aegypti* and Chio and Yang (2008) using Neem tree (*Azadirachta indica*) oil against *Ae. albopictus*. Besides, El- Sheikh *et al.* (2012) used methanolic extract of *Tribulus terrestris* (leaves & seeds) against *A. arabiensis* and found that the seeds extract was more effective repellent (100%) against the mosquito compared with leaves extract (79.5%) at dose 1.0 & 2.0mg/cm^2, and Adhikari and Chandra (2014) who found that petroleum ether leaf extract of *Swietenia mahagoni* against *A. stephensi* showed repellency up to 2hr after treatment. El-Hela *et al.* (2013) screened 110 Egyptian medicinal herbs and plants to evaluate their larvicidal activity against *Ae. aegypti*. They reported that the highly effective ones were *Coronilla scorpioides*, *Forsskaolea tenacissima*, *Crataegus sinaica*, *Pistacia khinjuk* and *Loranthus acacia* that exhibited the highest potency calculated as 22.53±2.01, 23.85±2.07, 28.17± 2.06, 31.60±2.93 & 39.73±4.58mg% aqueous extracts and 18.53±1.95, 18.8±1.67, 20.17±1.85, 23.28±2.7 & 28.48±3.9 mg% methanol ones respectively.

Conclusion

Searching for the new natural adulticides and larvicides become an urgent demand due to the health hazards accompanying the use of synthetic ones and the strict need of such environmental friend agents to decline many the health disasters caused by insect-borne infectious diseases.

Musa acuminata extracts used considered as new promising controlling and repellent agents for the mosquito vector, *C. pipiens.* Further, in near future we need to initiate studies leading to find the bioactive compounds in *M. acuminata* which may responsible for larvicidal and repellent activity.

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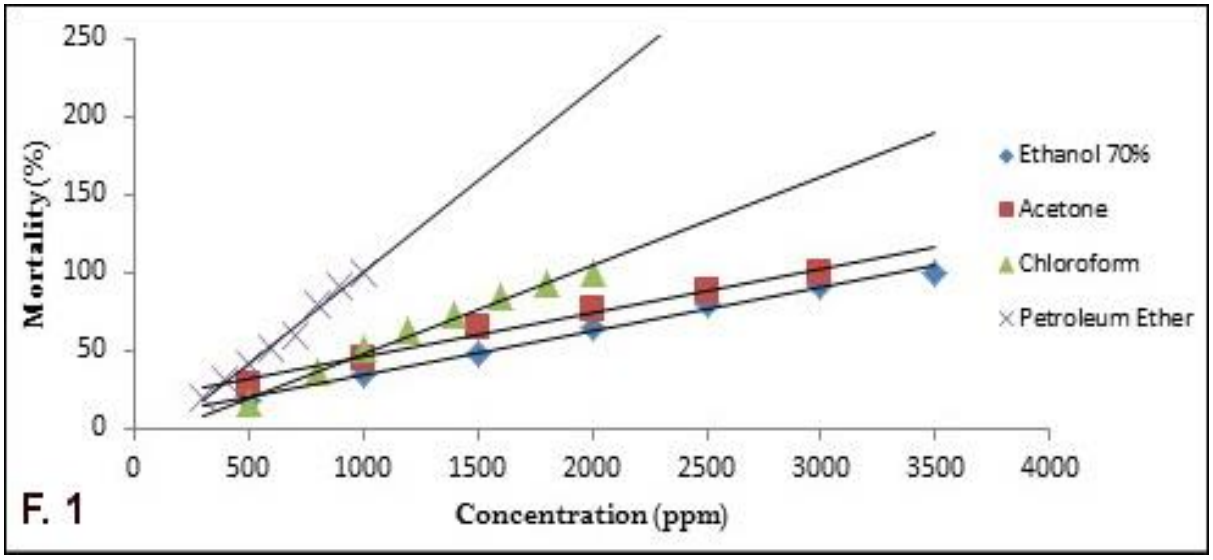

Fig. 1: Regression line of *C. pipiens* larval mortality as induced by tested *M. acuminata* extracts.