Brazilian Journal of Biological Sciences, 2018, v. 5, No. 10, p. 347-358.
ISSN 2358-2731
https://doi.org/10.21472/bjbs.051014

Entomocidal properties of *Monodora myristica* (Dunal, 1831) and *Conyza sumatrensis* (Retzius, 1742-1821) extracts: Studies on two dipterous insect pests *Anopheles gambiae* (Giles, 1902) and *Culex quinquefasciatus* (Say, 1823)

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Abstract. *Anopheles gambiae* (Giles, 1902) and *Culex quinquefasciatus* (Say, 1832) mosquitoes are the main vectors of human malaria and lymphatic filariasis, respectively. This study aims to analyze the larvicidal, pupicidal and adulticidal properties of *Monodora myristica* (Dunal, 1831) and *Conyza sumatrensis* (Retzius, 1742-1821) extracts against *An. gambiae* and *Cx. quinquefasciatus*. The experiment was conducted in the laboratory at ambient temperature of 28 °C ± 2 °C and 75% ± 5% relative humidity. The results showed that *M. myristica* and *C. sumatrensis* extracts significantly affect all stages of *An. gambiae* and *Cx. quinquefasciatus* tested. The mosquitocidal toxicity of the two plant extracts is dosage dependent. Anti-larval activity of *M. myristica* at rate 500 mg/L and 1,000 mg/L caused 100% mortality of *An. gambiae* larvae while it evoked 80% and 100% mortality of *Cx. quinquefasciatus* larvae. The same trend of results were also obtained on the anti-pupal and adulticidal toxicity of *M. myristica* and *C. sumatrensis* extracts. As larvicides, pupicides and adulticides, the LC_{50}s and LC_{90}s, after 24 h varied across plant extracts and mosquito species. *C. sumatrensis* attained LC_{50} and LC_{90} at higher concentration than *M. myristica.* On *An. gambiae* larvae, the LC_{50}s after 24 h, varied from 86.95 mg/L (*M. myristica*) to 131.73 mg/L (*C. sumatrensis*). Similarly, the LC_{90}s after 24 h on *An. gambiae* larvae, varied from 278.39 mg/L (*M. myristica*) to 131.73 mg/L (*C. sumatrensis*). For *Cx. quinquefasciatus* larvae, the LC_{50}s after 24 h , varied from 391.41 mg/L (*M. myristica*) to 898.20 mg/L (*C. sumatrensis*). The seed extract of *M. myristica* exerted the best pupicidal activity among the two tested extracts with LC_{50} and LC_{90} values of 140.61 mg/L and 520.35 mg/L on *An. gambiae*, respectively, followed by leaf of *C. sumatrensis* with LC_{50} and LC^{90} values of 157.59 mg/L and 781.86 mg/L on *An. gambiae,* respectively. More concentrations were require to achieve 50% and 90% death of *Cx. quinquefasciatus* pupae. On adulticidal activity, seed of *M. myristica* exerted LC_{50} and LC_{90} values of 122.79 mg/L and 502.99 mg/L on *An. gambiae*, respectively, followed by leaf of *C. sumatrensis* with LC_{50} and

Received
August 11, 2018

Accepted
August 30, 2018

Released
August 31, 2018

Full Text Article

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LC_{90} values of 215.05 mg/L and 981.25 mg/L on *An. gambiae,* respectively. More concentrations were require to achieve 50% and 90% death of *Cx. quinquefasciatus* adults. The two tested plants can be integrated into pest management programmes to combat human malaria and lymphatic filariasis vectors breeding site in Nigeria. I recommend formulation of *M. myristica* seeds which have the lowest LC_{50} and LC_{90} after 24 h of exposure for field evaluation.

Keywords: Entomocidal; *Monodora myristica*; *Conyza sumatrensis*; *Anopheles gambiae*; *Culex quinquefasciatus*.

Introduction

The dipterans are the most important orders of hexapods with veterinary and medical importance, which can transmit many pathogenic parasites causing diseases such as malaria and filariasis among the rural dwellers in the world (Sanei-Dehkordi et al., 2018). *Anopheles* and *Culex* mosquitoes are most dangerous vectors commonly find in tropical region (Okorie et al., 2014). About 40% of the world population live in this region (Pal et al., 2014) and this shows how preventive measurement is essential in this area. Despite the efforts made by World Health Organization and researchers over the past decades to decline the mortality rate of malaria and lymphatic filariasis all over the world, malaria disease are still household illness in the tropical regions of the world (Ileke et al., 2017; Vatandoost et al., 2018). Human malaria is the most important vector-borne disease caused by *Plasmodium* species transmitted by anopheline mosquitoes. About 212 million peoples were suffering from malaria with 429,000 deaths recorded worldwide (WHO, 2016). *Culex* species is the most medically important vectors of human pathogens causing etiologic agents of different forms of encephalitis, Rift valley fever and lymphatic filariasis that are still predominant in the tropical region (Vatandoost et al., 2018). Immediate intervention in the control of these vectors in the rural area where the breeding of mosquitoes appeared permanent or semi-permanent as a result of ignorance of the vectors on the part of rural dwellers.

Vectors control programme have been intensified by medical entomologists and parasitologists throughout the world with the use of botanicals in lieu of synthetic chemical insecticides which are toxic to untargeted organisms and natural enemies as well as high cost of purchase in the management of malaria and lymphatic filariasis vectors (WHO, 2013; Vatandoost et al., 2018).

Monodora myristica is a tropical tree of the Family Annonaceae. The plant is about 35 m high and 2 m in diameter. It has a clear trunk and branches horizontally (Fournier et al., 1999). The leaves are alternately arranged and drooping with the leaf blade being elliptical, oblong or broadest towards the apex and tapering to the stalk (Weiss, 2002). It is a flowering plant with the seeds containing 5%-9% of a colourless essential oil (Weiss, 2002). The plant is used as stimulants, stomachic, for headaches, sores and also as insect repellent. The seeds are also made into necklaces (Weiss, 2002). Previous studies have shown that its polar extracts possess insecticidal properties against cowpea beetle, *Callosobruchus maculatus* (Okosun and Adedire, 2010; 2017). It also possess ant-larval against *Aedes albopictus* (Tankeu et al., 2016)

Conyza sumatrensis is an annual, biennial or perennial herbaceous plant that belong to Family Asteraceae. The genus *Conyza* consists of about 80-100

described species (Beentje, 2002; Chai et al., 2008). The oil of *C. sumatrensis* have antimicrobial and antifungal effects (Deans et al., 1992). Liu et al. (2012) reported the antifugi activity of *C. sumatrensis* against *Phoma macrostoma*.

In view of the current trend of developing plant based insecticides as a substitute to synthetic chemical insecticides, this study was undertaken to evaluate the larvicidal, pupicidal and adulticidal properties of *M. myristica* (Dunal, 1831) and *C. sumatrensis* (Retzius, 1742-1821) extracts against *An. gambiae* (Giles, 1902) and *Cx. quinquefasciatus* (Say, 1823) mosquitoes, a major vector of malaria and lymphatic filariasis, respectively.

Materials and methods

Collection and rearing of larva, pupa and adult mosquitoes

Mosquito baits, consisting of shallow containers with a large surface area was established under a partial shade in an open field by filling the white bucket with rain water. 10 g of yeast (Bakers' yeast) were sprinkled on the surface of the water to serves as source of foods for the nourishment of larvae. Wild mosquitoes were allowed to freely visit the baits and to lay eggs. This was monitored for 4-6 days for the development of the egg and first larva instar. These larvae were taken into the laboratory for identification into species levels (Gillies and De Meillon, 1968). The *An. gambiae* and *Cx. quinquefasciatus* larvae were separated from the mixed culture and transferred into another plastic container containing rain water to get a pure culture of each of the two dipterous insects. Some of the larvae were used for the larvicidal tests. The *An. gambiae* and *Cx. quinquefasciatus* larvae were further nurtured to pupae for 4-6 days for pupicidal tests.

Adult mosquitoes that emerged were fed with 10% sucrose solution and periodically fed with blood of 5-7 weeks restrained chick (Afolabi et al., 2018). The reared mosquitoes were maintained at 28 °C ± 2 °C and 75% ± 5% relative humidity, 12 h light followed by 12 h dark photoperiod.

Collection of plant materials and extraction

The plants evaluated in this work were *M. myristica* seeds and *C. sumatrensis* leaves. The fully developed leaves of *C. sumatrensis*, free of insecticides were obtained in fresh form from the premise of Strategic Grains Reserve Oda Road, Akure, Ondo State. The seeds of *M. myristica* were collected from Erekesan Market, Akure, Ondo State. They were taken to the Biology Department, Federal University of Technology, Akure, Ondo State, for authentication by plant taxonomist. The leaves of *C. sumatrensis* were washed with distilled water, shade dried, cut into small pieces and air dried for 14 days in the laboratory. The seeds of *M. myristica* were also air dried for 21 days before pulverized into fine powders using an industrial electric pulverizing machine at the Department of Animal Production and Health Laboratory of the Federal University of Technology Akure. The powders were further sieved to pass through 1 mm^2 perforations and kept in an air-tight plastic containers for storage before use at ambient temperature 28 °C ± 2 °C.

About 300 g of *M. myristica* and *C. sumatrensis* powders were soaked separately in an extraction bottle containing 600 mL of absolute methanol for 72 h. The mixture was stirred occasionally with a glass rod and extraction was terminated after 72 h. Filtration was carried out using a double layer of Whatman No. 1 filter papers and solvent evaporated using a rotary evaporator at 30 °C to 40 °C with rotary speed of 3 to 6 rpm for 8 h (Udo, 2011). The resulting extracts was air dried in order to remove traces of solvent. The extracts were kept in labeled plastic bottles till when needed.

Preparation of standard stock solution

Standard stock solutions were prepared by dissolving 2 g of the crude extracts in 1 L of water. From these stock solutions, different concentrations of 62.5 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L were prepared and these aqueous solutions were used for the various experiment.

Larvicidal, pupicidal and and adulticidal bioassay

100 mm of aqueous solutions of the various plant extracts at various concentrations of 62.5 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L were each put in a labelled transparent bowl. 25 days old larvae of *Anopheles* and *Culex* mosquitoes were introduced separately into the various plant extracts. They were replicated four times and water was used as control. The number of dead larvae were counted and recorded accordingly after 24 h of treatment. Dead larvae were those incapable of rising to the surface or without the characteristic diving reaction when the water was disturbed (WHO, 2006; 2009).

$$\% \text{ Larval Mortality} = \frac{\text{Number of dead larvae}}{\text{Number of larvae introduced}} \text{ x } \frac{100}{1}$$

Similar experiment as described above was carried out for *An. gambiae* and *Cx. quinquefasciatus* pupae. 22 days old pupae of *An. gambiae* and *Cx. quinquefasciatus* were introduced separately into the various *M. myristica* and *C. sumatrensis* concentrations. They were replicated four times and water was used as control. The number of dead pupae were counted and recorded accordingly after 24 h of treatment.

20 *An. gambiae* and *Cx. quinquefasciatus* adults were introduced into separate round bottom conical flask that contain suspended filter papers soaked with 62.5 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L *M. myristica* and *C. sumatrensis* extracts separately for adult bioassay. They were replicated four times and water was used as control. Mortality of adult insect was accessed after 24 h of exposure.

Statistical analysis of data

Percentage larvae, pupae and adults mortalities were estimated and corrected according to Abbott's Formula (Abott, 1925). The log-Probit model analysis (Finney, 1971) was done to the data recorded in the larvicidal, pupicidal and adulticidal bioassay to assess the 50% and 90% lethal concentrations.

Results

Toxicity of Plant Extracts on *An. gambiae* and *Cx. quinquefasciatus* Larvae

Mortalities resulted from exposing the *An. gambiae* and *Cx. quinquefasciatus* larvae to different concentrations of *M. myristica* and *C. sumatrensis* extracts is presented in Table 1. Mortalities of larval stage of the tested mosquitoes, *An. gambiae* and *Cx. quinquefasciatus* occurred in a dosage-dependent manner.

Table 1. Toxicity of plant extracts on larvae *An. gambiae* and *Cx. quinquefasciatus* after 24 h of exposure.

Mosquitoes	Plant extracts	Concentration (mg/L)				
		62.5	125.0	250.0	500.0	1,000.0
An. gambiae	*M. myristica*	42.50±4.79^{c}	57.50±2.50^{c}	85.00±2.89^{c}	100.00±0.0^{c}	100.00±0.0^{b}
	C. sumatrensis	32.50±2.50^{b}	45.00±2.89^{b}	67.50±2.50^{b}	80.00±2.75^{b}	100.00±0.0^{b}
	Untreated	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Cx. quinquefasciatus	*M. myristica*	35.00±2.89^{c}	52.50 ±2.50^{c}	80.00±2.75^{c}	92.50 ±2.50^{c}	100.00±0.0^{b}
	C. sumatrensis	20.00±2.75^{b}	35.00±2.89^{b}	55.00±2.89^{b}	72.50±2.50^{b}	92.50±2.50^{b}
	Untreated	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}

All values are means of four replicate followed by ± Standard error of the mean. Mean followed by the same letters, superscript at the end of each value, down the column are not significantly different ($p > 0.05$) from one another using Tukey's Test.

There was significant differences ($p < 0.05$) in toxicity level of the two plant extracts on *An. gambiae* and *Cx. quinquefasciatus* larvae at concentration 62 mg/L, 125 mg/L, 250 mg/L and 500 mg/L. African nutmeg, *M. myristica* caused 42.5%, 57.5%, 85%, 100% and 100% mortality of *An. gambiae* larvae at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L, respectively.

C. sumatrensis extract at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L evoked 32.5%, 45%, 67.5%, 80% and 100% mortality of *An. gambiae* larvae, respectively.

African nutmeg, *M. myristica* caused 35%, 52.5%, 80%, 92.5% and 100% mortality of *Cx. quinquefasciatus* larvae at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L, respectively. *C. sumatrensis* extract at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L evoked 20%, 35%, 55%, 72.5% and 92.5% mortality of *Cx. quinquefasciatus*, respectively.

At concentration 1,000 mg/L, both plant extracts had 100% mortality on *An. gambiae* an effect that was not significantly different ($p > 0.05$) from mortality of *Cx. quinquefasciatus* larvae. Based on the results obtained, *M. myristica* caused more mortality of *An. gambiae* than *Cx. quinquefasciatus* larvae.

Toxicity of plant extracts on *An. gambiae* and *Cx. quinquefasciatus* pupae

Figure 1 showed the toxicity of *M. myristica* and *C. sumatrensis* extracts on *An. gambiae* and *Cx. quinquefasciatus* pupae. There was significant differences ($p < 0.05$) in toxicity level of the *M. myristica* and *C. sumatrensis* extracts on *An. gambiae* and *Cx. quinquefasciatus* pupae at concentration 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L. *M. myristica* evoked 35%, 50%, 70%, 87.5% and 100% mortality of *An. gambiae* pupae at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L, respectively.

C. sumatrensis extract at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L caused 25%, 40%, 62.5%, 85% and 92.5% mortality of *An. gambiae* pupae, respectively. *M. myristica* evoked 30%, 45%, 65%, 80% and 95% mortality of *Cx. quinquefasciatus* pupae at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L, respectively.

C. sumatrensis extract at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L caused 20%, 35%, 60%, 70% and 90% mortality of *Cx. quinquefasciatus* pupae, respectively.

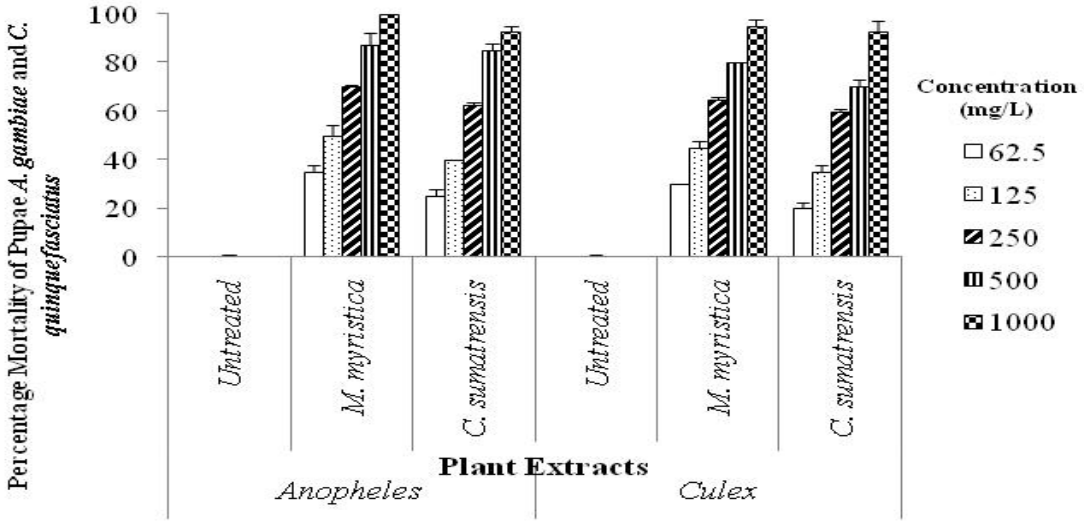

Figure 1: Toxicity of Plant Extracts on Pupae *Anopheles gambiae* and *Culex quinquefasciatus* mosquitoes after 24 hours of exposure.

Both *M. myristica* and *C. sumatrensis* extracts had 100% mortality on *An. gambiae* pupae an effect that was not significantly different ($p > 0.05$) from mortality of *Cx. quinquefasciatus* pupae. *M. myristica* caused more mortality of *An. gambiae* than *Cx. quinquefasciatus* pupae.

Fumigant toxicity of plant extracts on *An. gambiae* and *Cx. quinquefasciatus* adults

Figure 2 showed the fumigant toxicity of *M. myristica* and *C. sumatrensis* extracts on *An. gambiae* and *Cx. quinquefasciatus* adults after 24 h of exposure.

M. myristia extract caused more mortality of adults *An. gambiae* than *Cx. quinquefasciatus* after 24 h of exposure. There was significant different ($p < 0.05$) in the effects of *M. myristica* and *C. sumatrensis* extracts on adults *An. gambiae* and *Cx. quinquefasciatus* at rates 62 mg/L, 125 mg/L, 250 mg/L and 500 mg/L. *M. myristica* caused 32.5%, 47.5%, 67.5%, 90% and 100% mortality of *An. gambiae* adults at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L, respectively.

Cx sumatrensis extract at rates 62 mg/L, 125 mg/L, 250 mg/L, 500 mg/L and 1,000 mg/L evoked 20%, 27.5%, 50%, 77.5% and 92.5% mortality of *An. gambiae* adults respectively. *M. myristica* extract caused 30%, 45%, 62.5%, 85% and 97.5% mortality of *Cx. quinquefasciatus* adults at rates 62mg/L, 125mg/L, 250mg/L, 500mg/L and 1000mg/L respectively. *C. sumatrensis* extract at rates 62mg/L, 125mg/L, 250mg/L, 500mg/L and 1000mg/L caused 15%, 22.5%, 45%, 72.5% and 85% mortality of *Cx quinquefasciatus* adults respectively. *M. myristica* extract had the highest percentage of mortality of adults *An. gambiae* and *Cx. quinquefasciatus* at all tested concentrations.

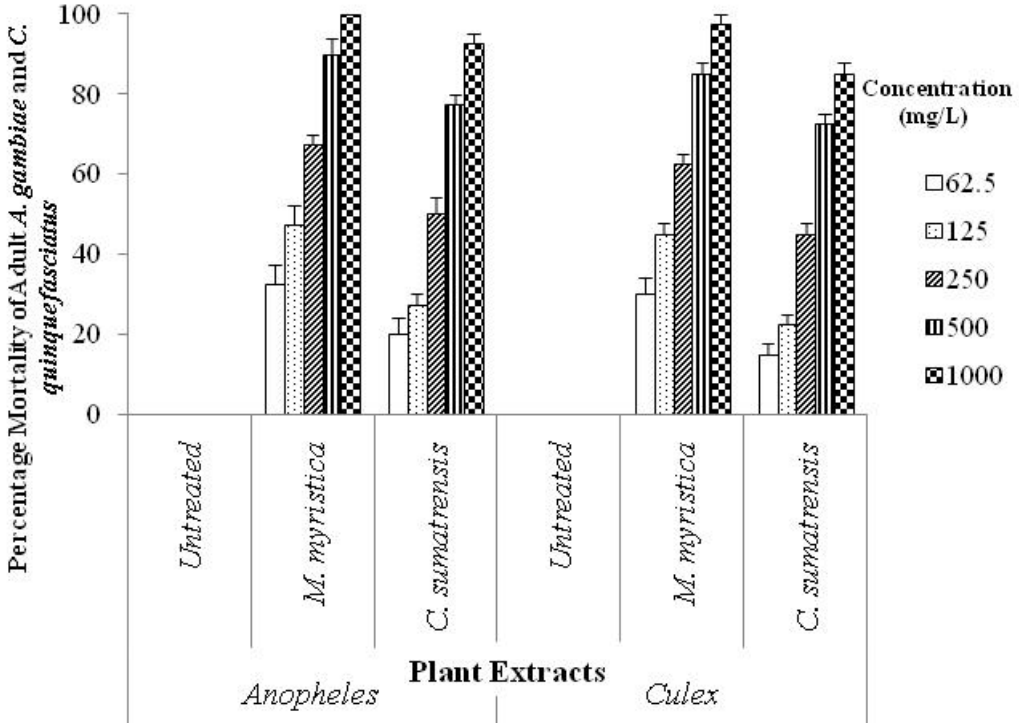

Figure 2: Fumigant Toxicity of Plant Extracts on Adult *Anopheles gambiae* and *Culex quinquefasciatus* mosquitoes after 24 hours of exposure.

LC_{50} and LC_{90} values calculated for the tested plant extracts

LC_{50} and LC_{90} of the *M. myristica* and *C. sumatrensis* extracts on *An. gambiae* and *Cx. quinquefasciatus* larvae, pupae and adults is presented in Table 2 and 3.

The LC_{50} of *M. myristica* extract was 86.95 mg/L while *C. sumatrensis* extract was 131.73 mg/L for *An. gambiae* larvae.

The concentration of *M. myristica* and *C. sumatrensis* extracts to cause 50% death of *Cx. quinquefasciatus* larvae were 103.83 mg/L and 189.48 mg/L, respectively. The LC_{90} of *M. myristica* extract was 278.39 mg/L while *C. sumatrensis* extract was 648.98 mg/L for *An. gambiae* larvae. The concentration of *M. myristica* and *C. sumatrensis* extracts to cause 90% death of *Cx. quinquefasciatus* larvae were 391.41 mg/L and 898.20 mg/L, respectively.

The concentration of *M. myristica* and *C. sumatrensis* extracts required to evoke 50% death of *An. gambiae* pupae were 115.22 mg/L and 157.59 mg/L, respectively. The LC_{50} of *M. myristica* extract was 140.61 mg/L while *C. sumatrensis* extract was 197.49 mg/L for *Cx. quinquefasciatus* pupae.

The concentration of *M. myristica* and *C. sumatrensis* extracts required to evoke 90% death of *An. gambiae* pupae were 520.35 mg/L and 781.86 mg/L, respectively. The LC_{90} of *M. myristica* and *C. sumatrensis* extracts were 803.78 mg/L and 1,051.47 mg/L for *Cx. quinquefasciatus* pupae, respectively.

The adult *An. gambiae* required 122.79 mg/L and 215.05 mg/L of *M. myristica* and *C. sumatrensis* extracts to cause 50% death. The LC_{50} of *M. myristica* and *C. sumatrensis* extracts

were 138.46 mg/L and 270.52 mg/L for *Cx. quinquefasciatus* adults, respectively.

The concentration of *M. myristica* and *C. sumatrensis* extracts required to evoke 90% death of *An. gambiae* adults were 502.99 mg/L and 981.25 mg/L, respectively. The LC_{90} of *M. myristica* and *C. sumatrensis* extracts were 664.46 mg/L and 1,330.48 mg/L for *Cx. quinquefasciatus* adults, respectively.

Table 2. LC_{50} of *M. myristica* and *C. sumatrensis* extracts on *An. gambiae* and *Cx. quinquefasciatus* larvae, pupae and adults.

Mosquito Developmental Stages	Mosquitoes	LC_{50} (lower-upper limit) of plant extracts	
		M. myristica	***C. sumatrensis***
Larvae	*An. gambiae*	86.92 (43.57-125.59)	131.73 (60.47-211.05)
	Cx. quinquefasciatus	103.83 (87.04-120.56)	189.48 (110.93-297.28)
Pupae	*An. gambiae*	115.22 (66.57-165.0)	157.59 (132.45-184.29)
	Cx. quinquefasciatus	140.61 (115.32-166.89)	197.49 (166.98-231.43)
Adults	*An. gambiae*	122.79 (72.59-176.03)	215.05 (184.95-249.13)
	Cx. quinquefasciatus	138.46 (115.78-162.02)	270.52 (232.14-316.22)

Table 3. LC_{90} of *M. myristica* and *C. sumatrensis* extracts on *An. gambiae* and *Cx. quinquefasciatus* larvae, pupae and adults;

Mosquito Developmental Stages	Mosquitoes	LC_{90} (Lower – Upper Limit) of Plant Extracts	
		M. myristica	***C. sumatrensis***
Larvae	*An. gambiae*	278.39 (184.7-758.22)	648.98 (362.21-935.75)
	Cx. quinquefasciatus	391.41 (323.07-503.02)	898.20 (500.85-1295.55)
Pupae	*An. gambiae*	520.35 (332.17-708.3)	781.86 (612.60-951.12)
	Cx. quinquefasciatus	803.78 (616.17-991.39)	1,051.47 (800.98-1,522.40)
Adults	*An. gambiae*	502.99 (321.24-684.74)	981.25 (767.11-1,195.39)
	Cx. quinquefasciatus	664.46 (525.47-910.24)	1,330.48 (1,009.59-1,651.37)

Discussion

The utilization of botanicals in vectors management is gaining interest as results of the hazard associated with synthetic chemical insecticides such as toxic wastes hazard and toxicity on non-targeted organism's couple with high

cost of purchase. Exploitation of low cost materials, such as agricultural wastes (cocoa pod, orange peel, cowpea pod), used in rural settlement against vectors of malaria and lymphatic filariasis may lead to promising control strategies in in developing countries (Sukumar et al., 1991; Tankeu et al., 2016). Many tropical plants have been reported to contain bioactive compound against stored product pests and vector of malaria (Adedire and Ajayi, 1996; Adedire and Lajide, 1999; Shaalan *et al.,* 200; Adedire, 2003; Adedire et al., 2011, Akinkurolere et al., 2011, Ileke and Ogungbite, 2015; Ileke et al., 2015; 2016; Awosolu et al., 2018). Presently, larvicidal, pupiidal and adulticidal properties of *M. myristica* seeds and *C. sumatrensis* leaves extracts on two dipterous insect pests. *An. gambiae* and *Cx. quinquefasciatus* has been investigated.

According to the results of this study, the *M. myristica* and *C. sumatrensis* extracts showed insecticidal effect on all stages of *An. gambiae* and *Cx. quinquefasciatus* tested. The mosquitocidal toxicity is dosage dependent; the higher the concentration, the higher the mortality rate of the vectors developmental stages. Anti-larval activity of *M. myristica* at rate 500 mg/L and 1,000mg/L caused 100% mortality of *An. gambiae* larvae while it evoked 80% and 100% mortality of *Cx. quinquefasciatus* larvae. The same trend of results were also obtained on the anti-pupal and aduticidal toxicity of *M. myristica* and *C. sumatrensis* extracts the two dipterous insects. The insecticidal potential of *M. myristica* extracted with five different solvents against cowpea bruchid, *Callosobruchus maculatus* have been reported by Okosun and Adedire (2010; 2017). Adedire (2003) made similar observation on the toxicity of Nutmeg in the control of *Callosobruchus maculatus.* The insecticidal activity of the *M. myristica* extract against two dipterous insects in this study may be due to the presence of various bioactive compounds such as alkaloids, terpenoids, phenolics, tannins and flavonoids (Vindhya et al., 2014; Tankeu et al., 2016). Emeasor et al. (2005) ascribed the effectiveness of *M. fragrans* to give a long term protection to cowpea seeds as result of active components such as phellandrene, p-cymene and limonene, which possess pesticidal properties.

Conyza sumatrensis is an annual, biennial or perennial herbaceous plant that belong to family Asteraceae. Exposure of *An. gambiae* and *Cx. quinquefasciatus* larvae, pupae and adults to a range of concentrations (62.5 mg/L-1,000 mg/L) caused mortalities ranged between 20%-100%. The toxicity of *C sumatrensis* to all the developmental stages of *Cx. quinquefasciatus* tested may be due to presence of limonene content in the essential extract as suggested by Sfara et al. (2009) and Kassir et al. (1989). African nutmeg, *M. myristica* extract had significant mosquitocidal activity than *C. sumatrensis* extract to all stages of *An. gambiae* and *Cx. quinquefasciatus* investigated. Kehail et al. (2017) reported 100% and 60% mortality of *Anopheles* and *Culex* mosquitoes larvae respectively when exposed to three plant extracts. This resistant may be due to the fact that *Cx. quinquefasciatus* mosquitoes is found majorly in the wild, plants and animal interactions might have physiological affected it toxicity compare with *An. gambiae* mosquito commonly found in human settlement in the study area (personal observation).

LC_{50} and LC_{90} increased as the mosquito developmental stage advanced. For larvae, pupae and adult mosquito, LC_{50} was more in *An. gambiae* compare with *Cx. quinquefasciatus*. Also *C. sumatrensis* attained LC_{50} and LC_{90} at higher concentration than *M. myristica.* As larvicides, pupicides and adulticides the LC_{50}s and LC_{90}s, after 24 h varied across plant extracts and mosquito species. On *An. gambiae* larvae, the LC_{50}s after 24 h, varied from 86.95 mg/L (*M. myristica*) to 131.73 mg/L

(*C. sumatrensis*). For *Cx. quinquefasciatus* larvae, the LC_{50}s after 24 h, varied from 103.83 mg/L (*M. myristica*) to 189.48 mg/L (*C. sumatrensis*). On *An. gambiae* larvae, the LC_{90}s after 24 h, varied from 278.39 mg/L (*M. myristica*) to 131.73 mg/L (*C. sumatrensis*). For *Cx. quinquefasciatus* larvae, the LC_{50}s after 24 h, varied from 391.41 mg/L (*M. myristica*) to 898.20 mg/L (*C. sumatrensis*). More concentrations were require to achieve 50% and 90% death of *Cx. quinquefasciatus* pupae.

Similar observation were reported by Tankeu et al. (2016) who worked on larvicidal activities of hydro-ethanolic extracts of three Cameroonian medicinal plants; *Syzygium guineense*, *M. myristica* and *Zanthoxylum heitzii* against *Aedes albopictus*. The seed extract of *M. myristica* exerted the best pupicidal activity among the two tested extracts with LC_{50} and LC_{90} values of 140.61 mg/L and 520.35 mg/L on *An. gambiae,* respectively, followed by leaf of *C. sumatrensis* with LC_{50} and LC_{90} values of 157.59 mg/L and 781.86 mg/L on *An. gambiae*, respectively. More concentrations were require to achieve 50% and 90% death of *Cx. quinquefasciatus* pupae. This ascribed to the report of Tankeu et al. (2016) who worked on larvicidal activities of three extracts against *Aedes albopictus*. On Adulticidal activity, seed of *M. myristica* exerted the best among the two tested plants with LC_{50} and LC_{90} values of 122.79 mg/L and 502.99 mg/L on *An. gambiae,* respectively, followed by leaf of *C. sumatrensis* with LC_{50} and LC_{90} values of 215.05 mg/L and 981.25 mg/L on *An. gambiae*, respectively. More concentrations were require to achieve 50% and 90% death of *Cx. quinquefasciatus* adults.

Conclusion

African nutmeg, *M. myristica* seeds and *C. sumatrensis* leaves extracts have shown significant larvicidal, pupicidal and adulticidal properties on *An. gambiae* and *Cx. quinquefasciatus* that causes human malaria and lymphatic filariasis. The two tested plants can be integrated into pest management programmes to combat human malaria and lymphatic filariasis vectors breeding site in Nigeria. The two plants are readily available in the trophic, ecofriendly, biodegradable and medicinal. I recommend formulation of *M. myristica* seeds which have the lowest LC_{50} and LC_{90} after 24 h for field evaluation in other to solve the problem of wild migration of vectors to human's settlement.

Acknowledgments

I thank Dr. F. A. Ologundudu of the Department of Biology, Federal University of Technology, Akure, Nigeria, for the identification of two plants evaluated in this study.

Conflict of interest statement

I declare that I have no conflict of interest.

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