

## Activities of Some Ethnobotanicals from North East Nigeria, against Culicine Mosquitoes

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### Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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### ABSTRACT

Mosquito borne diseases are the major cause of economic loss due to high morbidity and mortality in Africa. Elimination of culicine vectors using ethnobotanical extracts is one of the best methods for controlling mosquito-borne diseases. The methanolic and petroleum ether extracts of five plants, *Azadirachta indica* (neem), *Hyptis suaveolens* (bush tea), *Eucalyptus globulus* (pole wire), *Citrus senensis* (orange), and *Ocimumkilimanscharicum* (bush scent leaf), were investigated for their effectiveness in control of subfamilies *Culicidae* mosquitoes' larvae from June 2017 to October 2017. The results showed that the mortality is concentration dependent. Mortality was recorded for both methanol and petroleum ether extracts. Higher mortalities were observed in the methanolic extracts than petroleum ether extracts. The different plant extracts showed high significant differences ( $p < 0.05$ ) to each other. *Hyptis suaveolens* proved to be the most effective treatment agent with 100% mortality observed at both 150 ppm and 200 ppm. The present study has demonstrated larvicidal effects, and the effects were extended pupae emerged from the different treatment which led to the low adult emergence as compared to the control.

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## 1. INTRODUCTION

Mosquitoes are the most important insect group in terms of public health importance [1]. They transmit several numbers of infectious disease like malaria, filariasis, Dengue, Zika virus, Encephalitis, and others, causing millions of deaths every year [2], as also reported by Michigan mosquito control organization (MMCO, 2013). Eliminating the vectors of the diseases is an important step in the control of diseases. In time past synthetic pesticides have been developed and effectively used to eliminate mosquitoes and other storage pests [3]. However, the management of these disease vectors using chemical pesticides has partially failed, due to their efficiency in attaining physiological resistance [4]. In addition, the application of such chemicals has resulted in long-term harmful effects on non-target organism and other environmental component [5]. Most of the mosquito control programs target larval stage in breeding sites, since adulticides may only reduce the adult population temporary [6]. The conventional chemical method employed for this purpose includes insecticides, insect's growth regulators (IGRs), juvenile hormone compounds [7]. In addition, botanical products have been used traditionally by human communities and its application is easy. They are highly biodegradable and are considered as the safest methods for insects pest control [3] and vectors [1]. These plants are rich source of novel natural substances that can be used to develop environmental safe methods for insect control [8]. In recent time, chemicals derived from plants, fungus and nanoparticles from biological origin have been projected as weapons of future mosquito control programs as they are shown to be ecological friendly, biodegradable, cheaper, target specific and low toxicity to non-target organisms [9-13]. Moreover, plant-based products are mostly non-toxic to humans and other animals and have a high degree of biodegradable. Botanical can be used as an alternative to synthetic insecticides or along with other insecticides vector control programs. In view of the increasing interest in developing plant-based insecticides as an alternative to chemical insecticides the present study was undertaken to assess the larvicidal potential of the methanol and petroleum ether extracts and their extended effects on the pupae that emerged from the treated larvae.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

Plants [*Azadirachta indica* (neem), *Hyptis suaveolens* (bush tea), *Eucalyptus globulus* (pole wire), *Citrus senensis* (orange), and *Ocimumkilimanscharicum* (bush scent leaf)] material were collected from the study areas in June – July 2014 in five states of the north eastern region, Nigeria. The area is situated at latitude 9.082 and longitude 8.6753 and it is about 840KM from the age of the Sahara Desert and 475.5 meters above sea level. It falls within the Sudan savannah zone. The area is large and shares boundary with two other Nigerian geopolitical zones (north central and north western region) and also shares boundary with two (2) countries, including Cameroon, Chad.

### 2.2 Selection of Plant Material

For this study, a survey was carried out and five (5) plant species were selected from the states of North-eastern region (Adamawa, Borno, Gombe and Taraba) of Nigeria, and their organic molecules were extracted and tested against larval and adult mosquitoes. Twenty people were interviewed from each Local Government Area, for the types of plants and parts of plants that were in use against mosquitoes in the localities. Three local government areas from each state, one from each geopolitical zone were covered. Plant selection in the study area, were based on interviewing members of the community to specify the indigenous plant species known for their use in the regular control of mosquitoes and other insects in their localities. This species of plants was selected because of their popularity among the local and were ranked following the application of weighted criteria as described by Kweka et al. (2008). The plants were further selected by combining the ethno botanical leads and chemotaxonomic evidence (popularity of plants already used as insecticides by local people and documented evidence of insecticidal constituents in the family to which the candidate species belongs.

### 2.3 Collection of Plant Materials

Fresh leaves, fruit peels and whole plants were collected in study area and identified at the

Federal University Lokoja herbarium. The plants materials were shade dried, pounded into powdered form using mortar and pestle and stored in air tied polytene bags for soxhlet extraction. The extraction of oil with methanol and petroleum ether were done using soxhlet extractor.

## 2.4 Extraction of Crude Extracts

Clean boiling flasks (250 ml) were dried in the Oven at 110°C for about 30 minutes. Then transferred into desiccators and allowed to cool. About hundred grams each of the pulverized and air-dried plants powder weighed separately into extractor. The flask was filled with 200 ml of Methanol, then the extractor plugged tightly with cotton wool. The soxhlet apparatus were then assembled to allow for reflux for about 6hours. After six hours, the thimbles containing the sample were removed with care and the methanol and petroleum ether drained into the various containers for re-use. The various plants extract for both methanol and petroleum ether extracts were concentrated using water bath which removes the methanol and petroleum ether component living behind only the components of the various extracts, which were used for toxicity bioassay [14].

## 2.5 Mosquitoes Collection and Taxonomy

### 2.5.1 Toxicity bioassay

Third instar larvae were collected from the rice fields and some natural water bodies in Yola, Adamawa State, Nigeria. Larvicidal bioassay was also carried out in insectary prepared for the course of this study in Yola, Adamawa State. One milliliter of various plant extracts was measured and emulsified with 3 drops of Tween .<sup>+</sup>80 from a needle tip. The emulsified was made up to 1 liter with distilled water to form 1000ppm stock solutions. For all the stock solutions, serial concentration was prepared. The ranges start from 50 ppm, 100 ppm, 150 ppm, 200 ppm. From each concentration, 250 ml of all extracts was measured and introduce into separate labeled 500 ml of specimen bottles. Twenty 3<sup>rd</sup> instars larvae of Culicine mosquitoes were introduced to each beaker. Each treatment had five replicates. Mortality served as the end point of the test and result were used to determine the potential

efficacy of the various plant extracts. Larva was considered death if there was no moving or no response to gentle probing with a fine glass rod three times, 10 second each. Mortalities were recorded at after 36 hours post treatment for the various plant extracts and the control (only distilled water).

Analysis of variance (ANOVA) was used to determine significant differences between the mortality mean values, using Duncan multiple range test. Then LC50 and LC90 values were obtained through use of probit analysis.

## 3. RESULTS

### 3.1 Culicine Mosquito Species Found During the Study

Table 1, reveals that 1000 mosquito samples identified, were belong to five genera, *Aedes* 500(50%), *Culex* 350(35%), *Mansoni africanus* 146(14.6%) and *Toxorhynchites* 4(0.4%). Mosquito abundance in relation to species showed, that *Aedes aegypti* 309 (30.9%) proved to be the most abundant genus in study area, followed by *Culex quinquefasiatus* 231(23.1%). The least genus observed, was *Toxorhynchites* 4(0.4%)

### 3.2 Effects of Methanol Extracts on Culicine Development

The biological activity of the methanol and petroleum ether extracts of north eastern ethno-botanicals against the third instar larvae of *Culicine* mosquitoes have been studied. The biological activities included the *larvicidal*, pupal emergencerate, pupal mortality and adult emergence rate. Table 2, shows the biological activities of methanol extracts of ethno-botanicals against the 3<sup>rd</sup> instar larvae of *culicine*. Complete larval mortality (100%) was observed at the higher concentrations (150 ppm and 200 ppm) of *Hyptis suaveolens* and neem seed extracts (200 ppm). The Table also depicts that mortality increased with increase in concentration from 50 -200 ppm. The result showed that *H. suaveolens* proved to be the most effective treatment agent used during the experiment and no pupation (0.0%) was observed.

**Table 1. Mosquito species abundance in Yola**

Mosquito species	Number (%)	Total number (%)
<i>Aedes aegypti</i>	309(30.9)	500(50)
<i>Aedes albopictus</i>	191(19.1)	
<i>Culex quiquefasciatus</i>	231(23.1)	350(35)
<i>Culex fatigans</i>	119(11.9)	
<i>Mansoni africanus</i>	100(10)	146(14.6)
<i>Toxorhynchites</i>	4(0.4)	4(0.4)

Key: %= percentage

**Table 2. Effects of methanol extracts on *Culicine* development**

Plants	Conc. levels (PPM)	Larval mortality %	Pupation %	Pupal mortality (%)	Total mortality %	Adult emergence %
NS	50	36	64	4	40	60
	100	90	10	3	93	7
	150	93	7	3	96	4
	200	100	-	-	-	-
	Control	0	100	0	0	100
NST	50	20	80	6	26	74
	100	72	28	4	76	24
	150	81	19	0	81	19
	200	95	5	0	95	5
	Control	5	95	0	5	95
NL	50	10	90	0	10	90
	100	48	52	0	48	52
	150	67	33	0	67	33
	200	71	29	0	71	29
	Control	2	98	0	2	98
OK	50	18	82	3	21	79
	100	68	32	0	68	32
	150	79	21	0	79	21
	200	90	10	0	90	10
	Control	8	92	0	8	92
OP	50	35	65	0	35	65
	100	40	60	0	40	60
	150	45	55	3	48	52
	200	50	50	3	53	47
	Control	0	0	8	8	92
HS	50	50	50	8	58	42
	100	70	30	4	74	24
	150	100	0	0	100	-
	200	100	0	0	100	-
	Control	0	100	0	0	100
EG	50	48	52	8	56	44
	100	95	5	3	98	2
	150	98	2	1	99	1
	200	99	1	0	99	1
	Control	0	100	0	0	100

No. of larvae tested = 100; Replication =5; Conc. Level = Concentration levels, ppm= part per million- = all insects dead; Keys: HS = *Hyptis suaveolens*, OP = orange peels, OK = *Occimumkilimanscharikum*, EG = *Eucalyptus globulus*, NS = neem seed, NST = neem stem, NL = neem leaf

The effects of methanol extracts were also extended to the pupal stage, and therefore the adult emergence was also affected in all concentrations used, as compared to the control groups. The neem seed, neem stem, *O. killimanscharikum*, *Hyptis suaveolens* and *E. gloublus* were showed high percentage of mortalities of 68% or more at 100 ppm (Table 2).

Neem leaf extract showed 71% at 150 ppm. The least among the plant extracts was the orange peels that showed 50% lethality only at the highest concentration (200 ppm). A remarkable reduction in adult emergence was observed, at 200 ppm of *Hyptis suaveolens*, Neem seeds, *E. globulus*, neem stem and *O. kilimanscharicum*, with percentage emergence of 0%, 0%, 1%, 5%, and 10% respectively. Orange peels and neem leaf proved to be less effective for adult emergence with 47% and 29% respectively.

### 3.3 Larvicidal Effects of Methanol Extract on 3<sup>rd</sup> Instar Larvae of *Culicine*

The mean percentage mortality in Fig. 1 shows significant differences among the treatment agents within the groups. The control showed no significant difference among the group. The treated larvae showed significant differences ( $P < 0.05$ ) among all the treatment doses.

The results, showed that, the lower the concentration, the lower the mortality and the higher the concentration the higher the mortality. All the larvae treated with 50 to 200ppm doses showed significant differences ( $P < 0.05$ ) among all the treatment agents used during the experiment. The Neem seed extract (20) and *H. suaveolens* (20) showed highest effectiveness with 100% mortality at 200ppm followed by means of *E. globulus* (19.8), neem stem extract

(19) and *O. kilimanscharicum* (18). *H. suaveolens* (10) and *E. globulus* (10) proved to be the most effective treatment agents used at 50ppm dose, followed by neem seed (7.2) extract and orange peels (7.0) extracts, while neem leaves (2.0) proved to be the most ineffective treatment agent. *E. globulus* (19) extracts and neem seed (18) prove to be the most effective treatment agents used at 100ppm followed by Neem stem (14.4) extracts, *H. suaveolens* (14.0) and *O. kilimanscharicum* (13.6).

### 3.4 Effects of Petroleum Ether Extracts on *Culicine* Development

Table 3 shows the biological effects of petroleum ether extracts of ethno-botanical used against third instar larvae of *Culicine*. The highest mortality percentage (100%) was recorded at the higher concentration levels (150 and 200 ppm) of *H. suaveolens* and the lowest mortality percentage (20%) was observed at the lowest concentration levels (50 ppm) of orange peels. The pupation percentage of treated larvae are far much lower than the pupation of the untreated larvae. The pupation is concentration dependent. The total larval and pupal mortality percent were 50%, 60%, 100% and 100% at 50, 100, 150 and 200ppm of *H. suaveolens* respectively, as compared to 0.00% for the non-treated group.

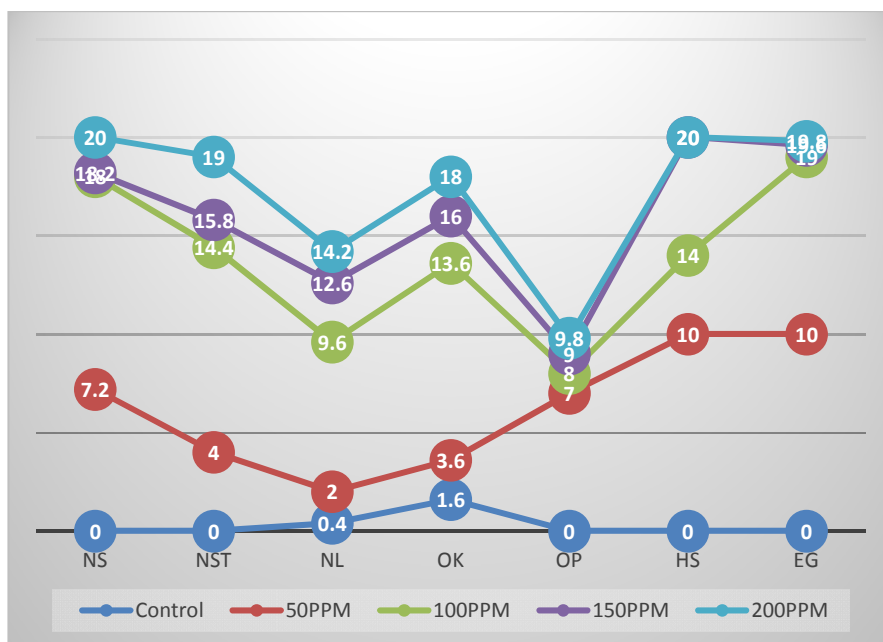


Fig. 1. Larvicidal effects of methanol extracts on 3<sup>rd</sup> instar larvae of *Culicine*

### 3.5 Larvicidal Effects of Petroleum Ether Extract on 3<sup>rd</sup> Instar Larvae of *Culicine*

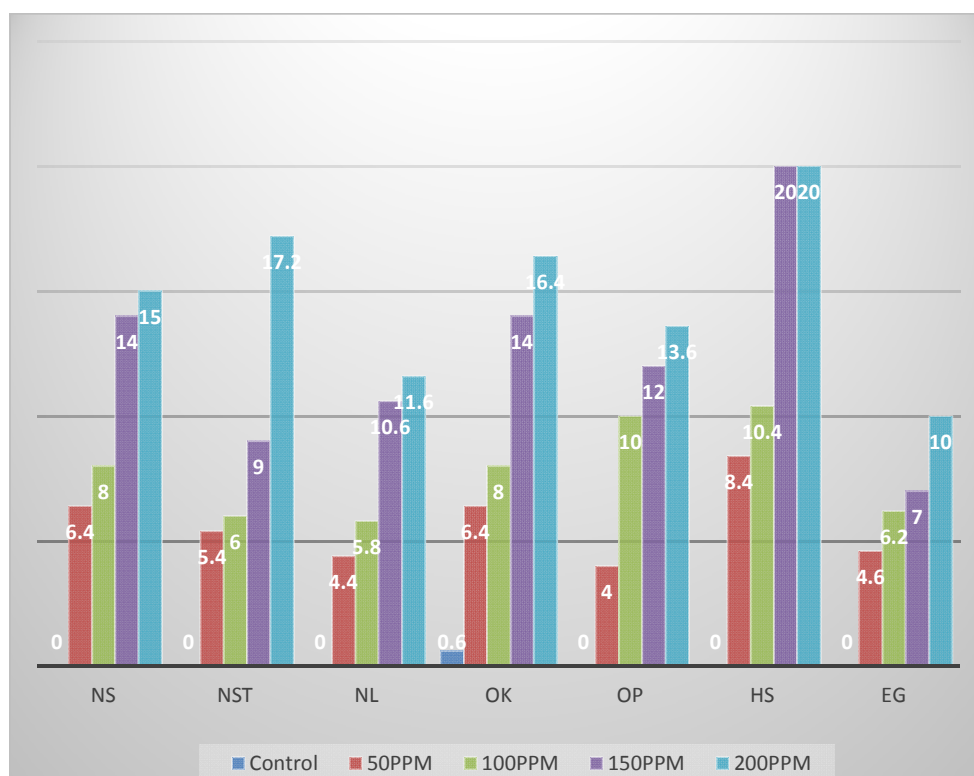
The data presented in Fig. 2, are the mean values of mortality of *Culicine* mosquitoes larvae due to the effects of various of plant extracts of petroleum ether that were tested against the 3<sup>rd</sup> instar larvae. The control column shows no significant differences among the treatment. The doses showed significant differences ( $p < 0.05$ ) among themselves. The figure reveals that 50 ppm showed significant difference ( $p < 0.05$ ) among the different extracts and had the lowest

means of mortality when compared to other doses used during the experiment, with *H. suaveolens* (8.4) being the most effective treatment agent at this dose. Treatments of 100 ppm showed significant difference ( $p < 0.01$ ) within themselves and *H. suaveolens* (10.4) had the highest mean mortality and neem leaf (5.8) had the least mortality mean at the dose. Treatment of 150 ppm showed significant difference ( $p < 0.001$ ) within themselves and same as 200 ppm dose. *Hyptis suaveolens* (20) proved to be the most effective treatment agent followed by neem stem extracts (17.2), neem

**Table 3. Effects of petroleum ether extracts on *Culicine* development**

Names	Conc. levels (PPM)	Larval mortality %	Pupation %	pupal mortality (%)	Total mortality %	Adult emergence %
NS	50	32	78	0	32	68
	100	40	60	0	40	60
	150	70	30	5	75	25
	200	76	24	6	82	18
	Control	0	100	0	0	100
NST	50	27	73	1	28	72
	100	30	69	2	32	68
	150	45	55	3	48	52
	200	86	14	5	91	9
	Control	0	100	0	0	100
NL	50	22	78	1	23	77
	100	29	71	0	29	71
	150	49	51	3	52	48
	200	58	42	1	59	41
	Control	2.0	98	0	2.	98
OK	50	34	66	4	38	62
	100	40	60	5	45	55
	150	70	30	6	76	24
	200	82	18	10	92	8
	Control	3	97	0	3	97
OP	50	20	80	0	20	80
	100	50	50	4	54	46
	150	60	40	0	60	40
	200	70	30	0	70	30
	Control	0	100	0	0	100
HS	50	42	58	8	50	50
	100	50	50	10	60	40
	150	100	-	-	100	-
	200	100	-	-	100	-
	Control	0	100	00	0	100
EG	50	23	77	0	23	77
	100	31	69	5	36	64
	150	35	65	7	42	58
	200	50	50	10	60	40
	Control	0	100	0	0	100

No. of larvae tested = 100; Replication =5; Conc. Level = Concentration levels, ppm= part per million - = all insects dead; Keys: HS = *Hyptis suaveolens*, OP = orange peels, OK = *Occimumkilimanscharikum*, EG = *Eucalyptus globulus*, NS = neem seed, NST = neem stem, NL = neem leaf



**Fig. 2. Larvicidal effects of petroleum ether extract on 3<sup>rd</sup> instar larvae of *Culicine***

seed extracts (15) and *O. kilimanscharikum* (16.4) The figure also depicts that the mean values of 200 ppm had the highest mortality means of 15, 17.2, 11.6, 16.4, 13.6, 20 and 10 for Neem seed, neem stem, neem leaves, *O. kilimanscharikum*, orange peels, *H. suaveolens* and *E. globulus* respectively, and higher than lower concentration levels.

### 3.6 Effects of Solvent Used in Extraction of Extracts on *Culicine* 3<sup>rd</sup> Instar Larvae

The result of the probit analysis shows various degree of effectiveness of some plant extracts used against 3<sup>rd</sup> instar larvae of *Culicine* mosquitoes. LC50 of petroleum ether extracts 100.25, 115.53, 145.88, 68.44, 114.55, 46.79, and 175.07 of neem seed, neem stem, neem leaf, *Ocimumkilimanscharicum*, orange peels, *Hyptism suaveolens* and *E. globulus* respectively, and when these were compared with LC50 of methanol extracts 45.91, 68.75, 126.56, 38.52, 141.73, 42.05 and 37.32, the result proved that methanol extracts were more effective than petroleum ether extracts (Fig. 3). The figure also showed that *E. globulus* (37.32) of methanol

extracts had the lowest concentration (LC50) that killed 50% of the 3<sup>rd</sup> instar larvae of *Culicine* mosquitoes, followed by *Ocimumkilimanscharikum* (38.52), *Hyptis suaveolens* (42.05), and neem seed (45.95) of the same methanol extracts, while orange peels (141.73) proved to be the most ineffective treatment agents of the extracts. The result also showed that *E. globulus* (93.12) and *Hyptis suaveolens* (107.15) of petroleum ether, killed 90% of 3<sup>rd</sup> instar larvae of *Culicine*. The *E. globulus* of methanol extract showed that 37.32 ppm killed 50% and 93.12 ppm killed and 90% of 3<sup>rd</sup> instar larvae of *Culicine* larvae that were exposed to it, and this proved that methanol extracts are far better than petroleum ether extracts (175.07 and 676.27ppm) of LC50 and LC90 respectively. Neem leaf (1985.93 ppm) and orange peels (526.18 ppm) of methanol extracts are the only extracts that showed toxicity effects against 3<sup>rd</sup> instar of *Culicine* when compared to their counterpart of petroleum ether extracts of neem leaf (530.05 ppm) and orange peels (387.89 ppm). All the extracts of both methanol and petroleum ether showed high degree of effectiveness, when compared with control that showed 0.0% mortality of 3<sup>rd</sup> instar larvae of *Culicine*.

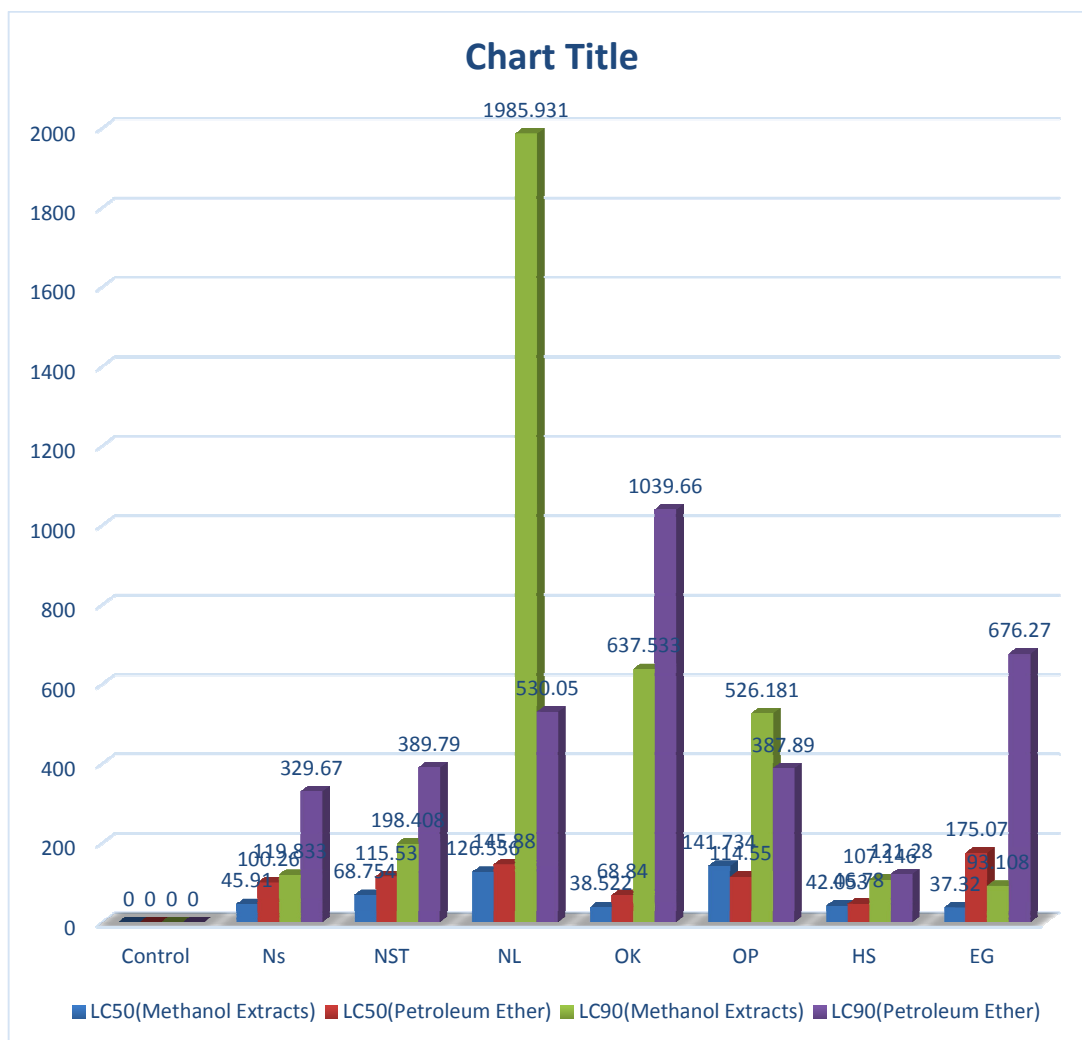


Fig. 3. Effects of solvent used in extraction of plants extracts on *culicine* 3<sup>rd</sup> instar larvae

#### 4. DISCUSSION

Several diseases are associated with the mosquito-human interaction. Mosquito are the carriers of several diseases that are of major problem in the public health system. The diseases include malaria, arbovirus, encephalitis, dengue fever, hikunguya, west Nile virus, yellow fever, zika virus and so on. These diseases produce significant morbidity in humans and livestock worldwide. The plants tested in this present study are well known to be eco-friendly and are non-toxic to non-targeted species. These plants are grown all over the north eastern state of Nigeria and some have been used as herbal medicine in the region. Moreover, it is proved that these plants have been used as mosquito repellent, through burning of smoke or hanging

them inside the rooms. The plants extracts are less expensive and highly efficacious for the control of mosquito rather than chemical compound [15,16]. The present study has shown high bioactivity of both methanol and petroleum ether extracts of the different plants. Such result may offer opportunity for developing alternative to rather expensive and environmental hazardous organic insecticides.

Toxicity of the tested plant extract against 3<sup>rd</sup> instar larvae varied according to the type of plants or the plant part and solvents used for the extraction and also the extracts concentration used. The larval mortality percent increased as the extract concentration increased in all the different plant extracts. The toxicity values of the tested extracts of the different ethnobotanicals on



mean value may be arranged in descending order as follows: *Hyptissuaveolen* > Neem seed > *E. globulus* > neem stem > *O. kilimanscharicum* > neem leaves > orange peels. These results agree, to some extent with the previous mentioned suggestions of Egunyomi et al. [16,17]. Extracts from several other plant species were tested on different mosquito species. The activity of plant extracts on larval mortality of culicine mosquitoes agreed with the result obtained by several researcher [5,15,1]. *H. suaveolens* proved to be the most effective treatment agent with 100% mortality recorded at 150 ppm and 200 ppm, followed by neem seed that showed 100% mortality at 200 ppm.

A remarkable decrease in pupation percent was induced by all plant extracts in the present study. The pupation percentage decreased as the concentration level of the plant extract increased. Moreover, the pupation rate depended on the type of plant species used. The present study showed that the toxic effect of all the ethnobotanical used had been extended to pupae. In addition, ethnobotanicals induced reduction of the adult emergence. The reduction was found to be concentration dependent. This result is comparable to earlier result of Sharma et al. [18] who also used petroleum ether extract of *A. annura* against *An. stephensi* and *Culex quinquefasciatus* which also showed the extension of the larvicidal effect to the pupal stage.

The results have shown that all the effect of the treatment agents of methanol and petroleum ether extracts used against culicine are significantly different from each other. The LC50 methanol extracts (37.32, 38.52, 42.05, 45.91, 68.75, and 126.56ppm) of *E. globulus*, *O. kilimanscharicum*, *H. suaveolens*, neem seed neem stem and neem leaf respectively, showed higher larvicidal effect than their counterpart petroleum ether extracts with LC50 (175.07, 68.44, 46.79, 100.25, 115.53, 145.88 ppm). The LC50 (114.5 ppm) petroleum ether extracts against culicine mosquito larvae proved to be better than its counterpart of methanol extracts with LC50 (141.73 ppm). The LC 90 values of methanol extracts (93.11, 107.12, 119.83, 198.42, 637.53 ppm) of *E. globulus*, *H. suaveolens*, neem seed, neem stem, *O. kilimanscharicum* respectively, are more effective than their counterpart petroleum ether extracts with LC90 (676.27, 121.28, 329.67, 389.72, 1039.66 ppm). This agrees with report of Naphtali et al., 2018 and Ngwamah et al. 2018,

Dixon 2015 that showed methanol extracts as the best agents against many mosquito species than some of the extracts from other solvents. This may be attributed to high polarity effect of the methanol as reported by Ngwamah et al. [19]. In the case of neem leave (198593 ppm) and orange peels (526.18ppm) of methanol extracts showed to be less effective against 3<sup>rd</sup> instar larvae of culicine mosquitoes as compared to their counterpart petroleum ether extracts with LC90 (530.05) of neem leaf and orange peels (387.89). this contrary to the findings of Kadri et al. [20], Dixon and Jeena [21] that reported that higher larvicidal effect of methanol extracts against larval mosquitoes than the petroleum ether extracts, but is in agreement with the report of Komalamisra et al. [22].

## 5. CONCLUSION

In general, it could be concluded that the crude extracts from all the plant material used during this study have larvicidal potential and some of the plant extracts have demonstrated extension of larvicidal effect to the pupal stage, where some pupae later died after pupation. This led to the low adult emergence as compared to the negative control. Furthermore, the result of the present study may contribute to the reduction in the application of synthetic chemical pesticides, which will increase the opportunity of natural control of various medically important pesticides by botanical insecticides.

## CONSENT AND ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Ito EE, Nmor JC, Ake JEG, Uteboe K. Larvicidal activities of *Pistia stratiotes* (water lettuce) against 3<sup>rd</sup> and 3<sup>rd</sup> instar larvae of *Aedes aegypti*. *Advances in Research*. 2015;3(6):589-595.
2. Arivoli S, Samuel T. Bioefficiency of *Citrullus colocynthis* (L.) shrub (Cucurbitaceae) whole plants extracts against *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus*

- (Diperaculicidea). International Journal of Current Research. 2011;3(4):296-304.
3. Ito EE, Ighere EJ. Bio-insecticidal potency of five plant extracts against cowpea weevil, *Callosobruchus maculatus* (F.), on Stored Cowpea, *Vigna unguiculata* (L). Jordan Journal of Biological Sciences. 2017;10(4):317-322.
  4. Elumalai K, Thangarasu M, Kaliyamoorthy K. Mosquito Larvicidal, pupicidal and pupicidal activities of *Abusprecatorious* Linn (Fabaceae) against dengue vector, *Aedes aegypti* (Linn), malarial vector, *Anopheles stephensi* (Liston), and *Filarial vector*, *C. quinquefasciatus* (SAY) (Diptera: Culicidae). Journal of Current Innovation Research. 2015;1(3):73-80.
  5. Patel EK, Gupta A, Oswal RJ. A review on: Mosquito repellent methods. International of pharmaceutical, Chemical and Biological Sciences. 2012;2:310-317.
  6. El-Hag EL, Abd-Ei R, El-nadi AH, Zaitoon AA. Effects of methanolic extracts of neem seeds on egg hatchability and larval development of culexpipiens mosquitoes. Indian Veterinary Journal. 2001;78:199-201.
  7. Hariral CC, Rathy MC, Sajith U. Larvicidal efficacy of medicinal plant extracts against the vector mosquito *Aedes albopictus*. International of Mosquito Research. 2015; 2(2):80-82
  8. Mandal S. Mosquito vector management with botanicals–The most effective weapons in controlling mosquito-borne diseases. Asian Pacific Journal of Tropical Biomedicine. 2012;336.
  9. Vivekanandhan P, Venkatesan R, Ramkumar G, Karthi S, Senthil-Nathan S, Shivakumar MS. Comparative analysis of major mosquito vectors response to seed-derived essential oil and seed pod-derived extract from *Acacia nilotica*. International Journal of Environmental Research and Public Health. 2018;15:388. DOI: 10.3390/ijerph15020388
  10. Vivekanandhan P, Senthil-Nathan S, Shivakumar MS. Larvicidal, pupicidal and adult smoke toxic effects of *Acanthospermum hispidum* (DC) leaf crude extracts against mosquito vectors. Journal of Physiological and Molecular Plant Pathology. 2017b;101:156-162.
  11. Vivekanandhan P, Deepa S, Kweka EJ, Shivakumar MS. Toxicity of *Fusarium oxysporum*-VKFO-01 derived silver nanoparticles as insecticidal potent against three mosquito vector species (Diptera: Culicidae). Journal of Cluster Science; 2018c. Available:https://doi.org/10.1007/s10876-018-1423-1.23456789
  12. Vivekanandhan P, Kavitha T, Karthi S, Senthil-Nathan S, Shivakumar MS. Toxicity of *Beauveria bassiana*-28 mycelial extracts on larvae of *Culex quinquefasciatus* mosquito (Diptera: Culicidae). International Journal of Environmental Research and Public Health. 2018d;15:440. DOI: 10.3390/ijerph15030440
  13. Vivekanandhan P, Karthi S, Shivakumar MS, Benelli G. Synergistic effect of entomopathogenic fungus *Fusarium oxysporum* extract in combination with temephos against three major mosquito vectors. Journal of Pathogens and Global Health; 2018e. Available:https://doi.org/10.1080/20477724.2018.1438228
  14. Amusan AAS, Idowu AB, Arowolo FS. Comparative toxicity effect of bush tea leaves (*Hyptis Conclu suaveolens*) and orange peel (*Citrus sinensis*) oil extract on larvae of the yellow fever mosquito *Aedes aegypti*. Tanzanian Health Research Bulletin. 2005;7:174-177.
  15. Kovendan K, Murugan K, Donald RB, Vicent S. Mosquito larvicidal properties of *Orthosiphon thymiflorus* (Roth) Sleensen. (family: Labiatae) against mosquito vectors, *Anopheles stephensi*, *Culex quinquefasciatus* and *Aede aegypti*. Asian Pacific Journal of Tropical Medicine. 2012;6(11):299-305.
  16. Egunyomi A, Gbadamosi IT, Osiname KO. Comparative effectiveness of ethno-botanical mosquito repellents used in Ibadan, Nigeria. Journal of Applied Biological Sciences. 2010;36:2383 -2388.
  17. Govnidarajan M, Sivakumar R. Adulticidal and repellent properties of indigenous plantextracts against *Culex quinquefasciatus* and *Aedes aegypti* (Dipetraculicidae). Journal of Parasitology Research. 2010; 109(2):353-367.
  18. Sharma P, Mohan L, Srivastava CN. Growth inhibitory nature of *Artemisia annua* extracts against *Culex quiquefasciatus* (Say). Journal of Asian Pacific Parasitic Entomology. 2006;9(4): 389-395.
  19. Ngwamah JS, Naphtali RS, Pukuma MS, Atiga A. Comparative insecticidal activity of

- five Nigerian plant species in Yola, Adamawa State, Nigeria. International Journal of Mosquito Research. 2018; 5(5):131-141.
20. Kadri A, Felhi, Daoud A, Hajloui H, Mnatgui K, Gharsalah N. Solvents extraction effect on phytochemical constituent's profiles, antioxidant and anti-microbial activities and functional group analysis of *Ecballium elaterium* seeds and peels fruits. Food Science and Technology. 2017;37(3):483-492.
21. Dixon D, Jeena G. Comparison of different solvents of phytochemical extraction of Potentials from *Datura* metal plant leaves. International Journal of Biological Chemistry. 2017;11:17-22.
22. Komalamisra N, Trongtokit Y, Rongsriyam Y, Apiwathnasorn C. Screening for larvicidal activity in some thai plants against four mosquito vector species southeast Asia Journal of Tropical Medicine of Public Health. 2006;36(6): 1412-1422.

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