Larvicidal Activity of Some Plants Extracts and Their Partitioned Fractions against *Culex quinquefasciatus*

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Authors’ contributions

This work was carried out in collaboration among all authors. Author FGF designed the study and performed the statistical analysis. Authors FGF and FBA wrote the first draft of the manuscript. Authors OJO and ORO carried out the larvicidal assay under the supervision of author FBA. Author FGF managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

**Aim:** The methanol extracts of fifteen plants and their partitioned fractions were screened for larvicidal activity against the fourth instar of larvae *Culex quinquefasciatus*, the vector of lymphatic filariasis with a view to identifying the active ones.

**Methodology:** The plant parts were collected, separately dried and milled. Each powdered material was extracted in methanol at room temperature for 3 days, with agitation. The extract was filtered and concentrated in vacuo. Each extract was tested against the fourth instar larvae of *Cx. quinquefasciatus*. The methanol extracts were suspended in water and successively partitioned into n-hexane and ethylacetate. Each partitioned fraction was also tested against the fourth instar larvae of *Cx. quinquefasciatus*.

**Results:** About fifty six percent (56.3%) of the tested extracts had moderate larvicidal activity after 48 hours. The fruit extract of *Thevetia nenifolia* and the leaf extracts of *Calotropis procera* and...
Solanum macrocarpon were the most active. After partitioning the methanol extracts, each of the plant extracts had one or two highly active partitioned fractions after 48 hours. The n-hexane fractions of S. macrocarpon (0.78 ± 0.03 mg/mL) and Spondias mombin (0.81 ± 0.03 mg/mL) were the most active.

Conclusion: The non-polar fractions of S. macrocarpon and S. mombin were the most active. Purification of these highly active fractions could lead to the isolation of potent larvicidal compounds that could be used in the control of Cx. quinquefasciatus mosquito.

Keywords: Larvicidal activity; filariosis; partitioned fraction; extracts; Culex quinquefasciatus.

1. INTRODUCTION

Lymphatic filariasis is a mosquito-borne parasitic disease that is endemic in many tropical and subtropical countries. This disease, caused by thread-like parasitic Wuchereria bancrofti, Brugia malayi or B. timori is transmitted by Culex quinquefasciatus and certain Anopheles species, and it is one of the neglected tropical diseases [1,2]. Controlling the vectors will go a long way in the control of the disease. The control of mosquito at the larva stage is efficient as they are relatively immobile and a large population can be killed in their breeding sites with little effort [3]. There is an increase in the development of resistance to currently available synthetic larvicides especially in the tropics [4]. The advantages of larvicides of plant origin over the synthetic ones cannot be overemphasised, and this has stimulated intensified efforts towards developing plant based larvicides. Search for eco-friendly, safe, low cost and potent plant-based larvicides for the control of mosquitoes need the preliminary screening of plants to evaluate their larvicidal potentials [5]. Plants that are used folklorically as fish poisons and in the treatment of malaria and fever, as well as those with reported insecticidal and insect repellent activities have been suggested as lead in the choice of plants to be screened for larvicidal activity [6]. Therefore, in this study, the methanol extract of fifteen plants possessing one or more of these characteristics and their partitioned fractions were screened for larvicidal activity against Cx. quinquefasciatus.

2. MATERIALS AND METHODS

2.1 Plants Collection

Each of the plants listed in Table 1 was collected at various locations in Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. They were identified by Mr. Ogunlowo of the Department of Pharmacognosy, Faculty of Pharmacy and voucher specimens were deposited at the Faculty of Pharmacy Herbarium.

2.2 Preparation of the Extracts and Fractions

The leaves were air-dried while the stem bark, fruit and roots were oven-dried at 35°C and then milled into fine powder using the Warring blender. The powdered plant parts were separately weighed and soaked in methanol for 72 hours with regular shaking. The extracts were filtered and concentrated in vacuo at 35°C and this process was repeated twice. Each of the extracts was suspended in water, successively partitioned with n-hexane and ethylacetate and concentrated in vacuo to get their corresponding fractions.

2.3 Evaluation of the Larvicidal Activity

Stock solution of each of the extracts (25 mg/mL) and fractions (5 mg/mL) was prepared by solubilising in Tween 80 and diluting with distilled water. They were serially diluted to obtain 25 mL of different concentrations of the test agents, 0, 1, 2, 3, 4, 5 mg/mL for extracts and 0, 0.5, 1.0, 1.5, 2.0 and 2.5 mg/mL for fractions). Twenty-five larvae were introduced into each cup and each concentration was replicated five times. The methanol extract of Nicotiana tabacum leaf, a known insecticidal plant was used as the positive control, and its toxicity was evaluated at 0.2 – 1.0 mg/mL while Tween 80 in distilled water was used as the negative control. The number of surviving larvae was counted after 24 and 48 hours of exposure during which no nutritional supplement was added [7]. The percentage mortalities were calculated and the LC50 and LC90 values were predicted using Microsoft Excel program 2010. The larvicidal activity of the extracts and their fractions were compared with that of the positive control and with each other by subjecting the values to statistical analysis using ANOVA and Student Newmann Keul’s post-hoc test. P < 0.05 was considered as significant.
<table>
<thead>
<tr>
<th>Name of plants</th>
<th>Family</th>
<th>Part used</th>
<th>Related activity</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthocleista vogelli</td>
<td>Gentianaceae</td>
<td>Bark</td>
<td>Fever; malaria</td>
<td>Anyawu et al., 2018 [8]</td>
</tr>
<tr>
<td>Calotropis procera</td>
<td>Asclepiadaceae</td>
<td>Leaf</td>
<td>Fever, malaria</td>
<td>Bairagi et al., 2018 [9]</td>
</tr>
<tr>
<td>Cassia sieberiana</td>
<td>Fabaceae</td>
<td>Root</td>
<td>Fever, malaria, termite resistant</td>
<td>Archer et al., 2019 [10]</td>
</tr>
<tr>
<td>Delonix regia</td>
<td>Fabaceae</td>
<td>Bark</td>
<td>Fever, malaria</td>
<td>Ahmed et al., 2009 [11]</td>
</tr>
<tr>
<td>Ficus exasperata</td>
<td>Moraceae</td>
<td>Leaf</td>
<td>Fever, malaria, insecticidal</td>
<td>Ahmed et al., 2012 [12]</td>
</tr>
<tr>
<td>Ficus sur</td>
<td>Moraceae</td>
<td>Leaf</td>
<td>Arrow poison, malaria</td>
<td>Maroyi, 2013 [13]</td>
</tr>
<tr>
<td>Ficus vogelli</td>
<td>Moraceae</td>
<td>Leaf</td>
<td>Malaria</td>
<td>Igile et al., 2015 [14]</td>
</tr>
<tr>
<td>Hilleria latifolia</td>
<td>Petiveriaceae</td>
<td>Leaf</td>
<td>Fever, malaria</td>
<td>Johnson et al., 2018 [15]</td>
</tr>
<tr>
<td>Momordica charantia</td>
<td>Cucurbitaceae</td>
<td>Leaf</td>
<td>Fever, malaria</td>
<td>Pani et al., 2015 [16]</td>
</tr>
<tr>
<td>Psidium guajava</td>
<td>Asclepiadaceae</td>
<td>Leaf</td>
<td>Fever</td>
<td>Naseer et al., 2018 [17]</td>
</tr>
<tr>
<td>Senna alata</td>
<td>Fabaceae</td>
<td>Leaf</td>
<td>Insecticidal</td>
<td>Adelowo and Oladeji, 2017 [18]</td>
</tr>
<tr>
<td>Solanum macrocarpon</td>
<td>Solanaceae</td>
<td>Leaf</td>
<td>Insect resistant</td>
<td>Kumar and Sadashiva, 1996 [19]</td>
</tr>
<tr>
<td>Spondias mombin</td>
<td>Anacardiaceae</td>
<td>Bark</td>
<td>Fever, malaria</td>
<td>Mitchell and Daly, 2015 [20]</td>
</tr>
<tr>
<td>Thevetia nerifolia</td>
<td>Apocynaceae</td>
<td>Bark and Fruit</td>
<td>Insecticidal</td>
<td>Rajbhar and Kumar, 2014 [21]</td>
</tr>
<tr>
<td>Vitex doniana</td>
<td>Verbanaceae</td>
<td>Bark</td>
<td>Fever, insect resistant</td>
<td>Ibrahim et al., 2013 [22]</td>
</tr>
</tbody>
</table>
### Table 2. Larvicidal activities of the extracts and partitioned fractions against *C. quinquefasciatus* at 24 hours

<table>
<thead>
<tr>
<th>S/N</th>
<th>Name of plant</th>
<th>Methanol extract</th>
<th>N-hexane fraction</th>
<th>Ethylacetate fraction</th>
<th>Aqueous fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LC&lt;sub&gt;50&lt;/sub&gt;</td>
<td>LC&lt;sub&gt;90&lt;/sub&gt;</td>
<td>LC&lt;sub&gt;50&lt;/sub&gt;</td>
<td>LC&lt;sub&gt;90&lt;/sub&gt;</td>
</tr>
<tr>
<td>1</td>
<td>Anthocleista vogelli</td>
<td>3.92 ± 0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.68 ± 0.03</td>
<td>1.82 ± 0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.13 ± 0.08</td>
</tr>
<tr>
<td>2</td>
<td>Calotropis procera</td>
<td>3.83 ± 0.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.91 ± 0.07</td>
<td>2.05 ± 0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.74 ± 0.36</td>
</tr>
<tr>
<td>3</td>
<td>Cassia sieberiana</td>
<td>6.28 ± 0.73&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.95 ± 1.36</td>
<td>2.96 ± 0.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.25 ± 0.50</td>
</tr>
<tr>
<td>4</td>
<td>Delonix regia</td>
<td>6.35 ± 0.49&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10.78 ± 0.91</td>
<td>3.06 ± 0.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.20 ± 0.45</td>
</tr>
<tr>
<td>5</td>
<td>Ficus exasperata</td>
<td>5.04 ± 0.41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.92 ± 0.76</td>
<td>2.66 ± 0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.91 ± 0.06</td>
</tr>
<tr>
<td>6</td>
<td>Ficus sur</td>
<td>12.23 ± 0.91&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.05 ± 0.50</td>
<td>6.52 ± 0.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.4 ± 1.02</td>
</tr>
<tr>
<td>7</td>
<td>Ficus vogelli</td>
<td>3.79 ± 0.25&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.23 ± 0.56</td>
<td>1.45 ± 0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.83 ± 0.17</td>
</tr>
<tr>
<td>8</td>
<td>Hilleria latifolia</td>
<td>8.29 ± 1.08&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.84 ± 2.02</td>
<td>3.62 ± 0.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.28 ± 0.14</td>
</tr>
<tr>
<td>9</td>
<td>Momordica charantia</td>
<td>5.01 ± 0.13&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.81 ± 0.12</td>
<td>4.05 ± 0.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.18 ± 0.33</td>
</tr>
<tr>
<td>10</td>
<td>Psidium guajava</td>
<td>4.52 ± 0.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.86 ± 0.04</td>
<td>3.96 ± 0.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.63 ± 1.29</td>
</tr>
<tr>
<td>11</td>
<td>Senna alata</td>
<td>5.23 ± 0.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.28 ± 0.03</td>
<td>1.61 ± 0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.98 ± 0.27</td>
</tr>
<tr>
<td>12</td>
<td>Solanum macrocarpon</td>
<td>3.34 ± 0.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.46 ± 0.24</td>
<td>0.93 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.83 ± 0.19</td>
</tr>
<tr>
<td>13</td>
<td>Spondias mombin</td>
<td>7.90 ± 1.16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.48 ± 2.20</td>
<td>0.83 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.65 ± 0.05</td>
</tr>
<tr>
<td>14</td>
<td>Thevetia nerifolia bark</td>
<td>4.75 ± 0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.83 ± 0.09</td>
<td>1.60 ± 0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.04 ± 0.10</td>
</tr>
<tr>
<td>15</td>
<td>Thevetia nerifolia fruit</td>
<td>3.64 ± 0.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.84 ± 0.09</td>
<td>1.64 ± 0.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.69 ± 0.19</td>
</tr>
<tr>
<td>16</td>
<td>Vitex doniana</td>
<td>10.81 ± 0.36&lt;sup&gt;c&lt;/sup&gt;</td>
<td>18.23 ± 0.25</td>
<td>1.27 ± 0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.51 ± 0.11</td>
</tr>
</tbody>
</table>

**Key:** LC<sub>50</sub> and LC<sub>90</sub>: Concentration in mg/mL that killed 50 and 90% respectively; a-d: LC<sub>50</sub> values with different superscripts across the rows are significantly different (P=0.05, one-way analysis of variance followed by the Student–Newman–Keuls’ test)
Table 3. Larvicidal activities of the extracts and partitioned fractions against *C. quinquefasciatus* at 48 hours

<table>
<thead>
<tr>
<th>S/N</th>
<th>Name of plant</th>
<th>Methanol extract</th>
<th>N-hexane fraction</th>
<th>Ethylacetate fraction</th>
<th>Aqueous fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LC₉₀</td>
<td>LC₅₀</td>
<td>LC₉₀</td>
<td>LC₅₀</td>
</tr>
<tr>
<td>1.</td>
<td>Anthocleista vogelli</td>
<td>2.84 ± 0.13</td>
<td>5.31 ± 0.01</td>
<td>1.20 ± 0.02</td>
<td>2.33 ± 0.04</td>
</tr>
<tr>
<td>2.</td>
<td>Calotropis procera</td>
<td>2.06 ± 0.09</td>
<td>4.26 ± 0.06</td>
<td>1.30 ± 0.04</td>
<td>2.45 ± 0.06</td>
</tr>
<tr>
<td>3.</td>
<td>Cassia sieberiana</td>
<td>6.36 ± 0.49</td>
<td>11.62 ± 0.87</td>
<td>1.90 ± 0.10</td>
<td>3.31 ± 0.21</td>
</tr>
<tr>
<td>4.</td>
<td>Delonix regia</td>
<td>5.09 ± 0.70</td>
<td>8.88 ± 1.35</td>
<td>1.72 ± 0.11</td>
<td>3.02 ± 0.18</td>
</tr>
<tr>
<td>5.</td>
<td>Ficus exasperata</td>
<td>3.65 ± 0.16</td>
<td>6.42 ± 0.28</td>
<td>1.70 ± 0.12</td>
<td>3.26 ± 0.22</td>
</tr>
<tr>
<td>6.</td>
<td>Ficus sur</td>
<td>10.17 ± 0.25</td>
<td>16.83 ± 0.30</td>
<td>4.03 ± 0.14</td>
<td>7.13 ± 0.29</td>
</tr>
<tr>
<td>7.</td>
<td>Ficus vogelli</td>
<td>3.37 ± 0.13</td>
<td>5.45 ± 0.35</td>
<td>1.32 ± 0.11</td>
<td>2.59 ± 0.21</td>
</tr>
<tr>
<td>8.</td>
<td>Hilleria latifolia</td>
<td>6.70 ± 0.97</td>
<td>12.08 ± 1.80</td>
<td>2.33 ± 0.16</td>
<td>4.17 ± 0.32</td>
</tr>
<tr>
<td>9.</td>
<td>Momordica charantia</td>
<td>4.61 ± 0.15</td>
<td>7.71 ± 0.03</td>
<td>1.53 ± 0.04</td>
<td>2.96 ± 0.08</td>
</tr>
<tr>
<td>10.</td>
<td>Psidium guajava</td>
<td>3.85 ± 0.35</td>
<td>7.27 ± 0.14</td>
<td>2.39 ± 0.25</td>
<td>4.33 ± 0.45</td>
</tr>
<tr>
<td>11.</td>
<td>Senna alata</td>
<td>4.16 ± 0.28</td>
<td>7.43 ± 0.05</td>
<td>1.34 ± 0.15</td>
<td>2.60 ± 0.25</td>
</tr>
<tr>
<td>12.</td>
<td>Solanum macrocarpon</td>
<td>2.35 ± 0.05</td>
<td>4.22 ± 0.13</td>
<td>0.78 ± 0.03</td>
<td>1.55 ± 0.07</td>
</tr>
<tr>
<td>13.</td>
<td>Spondias mombin</td>
<td>5.85 ± 0.70</td>
<td>10.43 ± 1.25</td>
<td>0.81 ± 0.03</td>
<td>1.51 ± 0.07</td>
</tr>
<tr>
<td>14.</td>
<td>Thevetia nerifolia</td>
<td>3.66 ± 0.12</td>
<td>6.02 ± 0.02</td>
<td>1.22 ± 0.06</td>
<td>2.30 ± 0.09</td>
</tr>
<tr>
<td>15.</td>
<td>Thevetia nerifolia</td>
<td>2.85 ± 0.04</td>
<td>5.01 ± 0.02</td>
<td>1.01 ± 0.05</td>
<td>2.04 ± 0.08</td>
</tr>
<tr>
<td>16.</td>
<td>Vitex doniana</td>
<td>7.54 ± 0.61</td>
<td>12.93 ± 1.24</td>
<td>0.78 ± 0.01</td>
<td>1.55 ± 0.01</td>
</tr>
<tr>
<td>17.</td>
<td>Nicotiana tabacum</td>
<td></td>
<td></td>
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<td>1.51 ± 0.18</td>
</tr>
</tbody>
</table>

Key: LC₉₀ and LC₅₀: Concentration in mg/mL that killed 50 and 90% respectively; a-d: LC₅₀ values with different superscripts across the rows are significantly different (*P* = 0.05, one-way analysis of variance followed by the Student–Newman–Keuls’ test)
3. RESULTS AND DISCUSSION

3.1 Results
The results of the activities of the methanol extracts and the partitioned fractions are as presented in Tables 2 and 3.

3.2 Discussion
Diseases such as filariasis, dengue fever, yellow fever, malaria, Japanese encephalitis and chikungunya transmitted by mosquitoes are still major health problems in most countries [23]. Even though chemical control program has been carried out for a long time, these mosquitoes remain because of the development of resistance to the available synthetic products [24]. This has necessitated the continued search and development of environmentally safe, biodegradable, and low cost chemical compounds from plants which can be used by individuals and communities in specific situations. There is therefore a provocative interest in research for larvicidal compounds from natural sources [25]. In this study the methanol extract of fifteen plants were screened. At 24 hours, five of the plant extracts namely A. vogelli, C. procera, F. vogelli, S. macrocarpon and T. neriifolia had moderate larvicidal activity (2.0 < LC50< 4.2 mg/mL) while the remaining eleven extracts (68.75%) had low activity with LC50>4.2 mg/mL [6,26]. After 48 hours of exposure to these test agents, the activities of F. exasperata, P. guajaya, S. alata and T. neriifolia bark improved making the moderately active ones to be 56.3% (Table 3). It had been earlier suggested that plant extracts which have some degrees (moderate or low) of activity should be fractionated and tested before discarding them [27]. Therefore, these methanol extracts were suspended in water, successively solvent partitioned and tested against Cx. quinquefasciatus larvae.

Anthocleista vogelli Planch bark: The methanol extract of A. vogelli bark, commonly called cabbage tree, was moderately active against the test organism. The essential oils from the leaf and stem bark obtained by hydrodistillation was highly toxic to the third instars larvae of Culex mosquito [28]. The n-hexane and the ethylacetate fractions had comparable activities at 24 hours while the aqueous fraction was inactive. There was a significant improvement in the activity of the n-hexane fraction at 48 hours making it the most active fraction. There was no previous report of the larvicidal activity of the extract of any of its morphological parts in literature.

Calotropis procera leaf: The moderate activity of the methanol extract was in line with previous reports on the aqueous leaf extract having remarkable larvicidal, adult emergence inhibitor, repellent and oviposition deterrent effects against mosquito species and Musca domestica [29-31]. The n-hexane fraction and ethylacetate fraction had better activity than the aqueous fraction and the extract throughout the test period.

Cassia sieberiana root DC: The root extract was inactive till 48hours despite the significant (p<0.05) inhibition of the hatching of the eggs of Haemonchus contortus, a gastrointestinal parasite by its leaf and root extracts [32]. Larvicidal activity had been reported for the leaf extract of Cassia fistula and the seed extract of Cassia tora and Cassia occidentalis against Cx. Quinquefasciatus [33-35] but there was no previous report for C. sieberiana. After partitioning, all the resulting fractions had better activity than the extract. The n-hexane and ethylacetate fractions were comparably more active than the aqueous fraction.

Delonix regia (Boj.exHook.) Raf. Bark: The low activity of the methanol extract of the bark in this study is similar to the low mortality reported for the ethanol and aqueous extracts of the seed against the larvae of An. gambiae [36]. The high activity of the various solvent extracts and the essential oil of the flower against mosquitoes, leaf-eating caterpillars and beetles like Hyblaea pueria, Sitophilus zeamais, Calosobruchus maculatus and Pericallia ricini had been reported [37-39]. This may imply that the larvicidal compound(s) of this plant is concentrated in the flower. The n-hexane and ethylacetate partitioned fractions of the bark extract used in this study had high larvicidal activities while the aqueous fraction was inactive. The activity of the aqueous fraction greatly improved at 48 hours.

Ficus exasperata Vahl, Ficus sur Forssk and Ficus vogelli Miq. Leaves: The methanol extract of F. vogelli was the most active, followed by F.exasperata while F. sur was the least active throughout the test period. High activity had been reported for the aqueous and ethanol extracts and the powder of F. exasperata leaf against snails, C. maculatus and S. zeamais [12]. The inactivity of F. sur methanol extractin this study was contrary to an earlier report of high activity [40]. There is no previous report of the larvicidal activity of F. vogelli against any vector. The
methanol extract of Ficus benghalensis, a related species, showed good larvicidal activity against Cx. quinquefasciatus [23] while glunol acetate, potent against fourth instar larvae of Ae. aegypti, An. stephensi and Cx. quinquefasciatus was isolated from the moderately active acetone extract of F. racemosa bark [41]. The n-hexane fraction of F. vogelli and F.exasperata were the most active while for F. sur, the aqueous fraction was the most active.

Hilleria latifolia (Lam.) H. Walter leaf: The extract had low activity against the test organism throughout the test period (Tables 2 and 3). This is the first report of the larvicidal activity of this plant extract against Cx. quinquefasciatus larvae. Partitioning the extract gave a moderately active n-hexane and ethylacetate fractions at 24 hours with improvement after 48 hours of exposure. Their activities were significantly less than that of N. tabacum, the positive control used. However, their purification can lead to the isolation of potent larvicidal compounds. For example, the n-hexane fraction of Bighia sapida extract was not as active as Endosulphan (a commercial insecticide) but its purification led to the isolation of friedelin and α-amyrin with high activities against Ae. aegypti [42].

Momordica charantia L. leaf: The low activity of M. charantia leaf extract in this study is contrary to the high activity reported against Ae. aegypti larvae [43]. This could be due to the difference in the mosquito species and the method of extraction; in that report; Soxhlet method was used while in this study, maceration was used. Also, the hexane extract and the nanopowder of the fruit had higher activity than the methanol extract used in this study against Cx. quinquefasciatus and Cx. pipiens [44]. The activity of all the partitioned fractions was not significantly better than that of the extract at 24 hours. At 48 hours, the high activity of the n-hexane fraction is in line with the 100% mortality reported for the hexane extract [45]. Non-polar characteristics of larvicidal components of the fruit extract against fourth instars larvae of An. stephensi, Cx. quinquefasciatus and Ae. aegypti had been demonstrated [46]. Momordicine II and IV isolated from the butanol fraction of this plant deterred oviposition of Liriomyza trifolii (a major leaf miner pest of a wide variety of vegetables, floricultures, and ornamental plants) significantly [47].

Psidium guajava L. leaf: The low activity of the leaf methanol extract at 24 hours improved slightly at 48 hours. The observed activity was similar to earlier reports against Ae. aegypti mosquito [48]. However, the essential oil and its major compounds 1, 8-cineole and carvacrol exhibited significant larvicidal activity against Ae. aegypti, Trogoderma granarium and Chaoborus plumicornis [49]. There was no significant improvement in the activity of the resulting partitioned fractions; the most active n-hexane fraction had comparable activity with the extract while the others were worse off. At 48 hours, n-hexane fraction was the most active while the ethylacetate and aqueous fractions maintained their low activity.

Senna alata L. (Roxb) leaf: The S. alata (synonym Cassia alata) leaf extract had low activity throughout the test period. This differed from the high activity reported against An. gambiae, Cx. quinquefasciatus and Ae. aegypti [50-52]. Moderate activities had been reported for some other species of Cassia like Cassia areeh stem bark methanol extract against C. quinquefasciatus, the seed petroleum ether extract of C. siamea leaf aqueous extract, S. auriculata, S. tora and C. fistula against An. stephensi and Ae. aegypti, ethanol extract of C. occidentalis leaf [53-55]. Partitioning the extract gave a highly active n-hexane and ethylacetate fractions. Similarly, the hexane extract of the fruit caused high lethality to Callosobruchus chinensis [56].

Solanum macrocarpon L. leaf: The extract was moderately active against the test organism. There had been reports of the larvicidal activity of Solanum nigrum leaf and berry extract and the phytosteroid isolated from the leaf against Ae. aegypti, Cx. vishnui and An. subpictus [57,58]. The potential of the methanol extract and fractions of the green fruits of Solanum lycocharpum against Cx. quinquefasciatus, aqueous extract of S. tuberosum tuber against Cx. quinquefasciatus and An. stephensi had also been previously reported [59,60] but there is no previous report on this species. The n-hexane fraction was highly active at both 24 and 48 hours followed by the ethylacetate fraction while the aqueous fraction was inactive. The high activity of the n-hexane fraction in the study was similar to the high activity reported for the petroleum ether extract of Solanum trifolatum [61].

Spondias mombin L. bark: Despite the low activity demonstrated by S. mombin bark extract, its partitioning resulted into a highly active n-
hexane fraction. This was the trend of activity for the leaf methanol extract and its n-hexane fraction against Cx. quinquefasciatus and Ae. aegypti [62]. However dichloromethane fraction was the most active in the adulticidal and repellency assays against adult Ae. aegypti mosquito [63,64]. The aqueous fraction was moderately active at 48 hours while the ethylacetate fraction had comparable activity to the extract throughout the test period.

*Thevetia nerifolia* L. fruit and bark: The extract of *T. nerifolia* (syn. *Thevetia peruviana*) fruit and bark had moderate and low activities respectively at 24 hours. Contrarily, its various leaf extracts, gave promising effects on the larvae of *Culex*, *An. stephensi* and *Ae. aegypti* mosquito and *M. domestica* in previous reports [65-67]. Also, the methanol extract of the stem reportedly had antifeedant and stomach poison activities [68] while the latex caused significant reduction in larval weight and very high larval mortality against *Spodoptera litura* [69]. Partitioning the extracts of both morphological parts led to hexane and ethylacetate fractions with high activities. The hexane and ethylacetate fractions of the bark had comparable activity at both hours while the ethylacetate fraction of the fruit was the most active.

*Vitex doniana* L. bark: The very low activity observed for the bark methanol extract at both 24 and 48 hours is similar to the report of the ethanol extract of the leaf against *Anopheles* mosquito [70]. High larvicidal activity was reported for the essential oil and leaf methanol extract of *Vitex negundo* and *Vitex trifolia* against Cx. quinquefasciatus and *Ae. aegypti* [71-73]. Throughout this study period, the n-hexane partitioned fraction was highly active while the ethylacetate fraction was moderately active.

4. CONCLUSION

About fifty six (56.3%) percent of the tested plants had moderate activity against *Cx. quinquefasciatus* larvae while the remaining ones had low activity. This is the first report of the larvicidal activity of the methanol extract of *A. vogelli*, *C. sieberiana*, *F. vogelli*, *H. latifolia* and *S. macrocarpon*. Each of the moderate and low acting extracts had one or two highly active fractions after 48 hours supporting the suggestion of fractionating plant extracts with some degrees (moderate or low) of activity. The compounds responsible for larvicidal activity of these plants have not been identified; therefore purification of each of these highly active fractions could lead to the isolation of potent larvicidal compounds that could be used in the control of *Cx. quinquefasciatus* mosquito.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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