4.1 Larvicidal activity of leaf and seed crude extracts

Larvicidal activity of three plant leaf and seed extracts with five different solvents was tested against the larvae of three important vector mosquitoes viz., *Cx. quinquefasciatus*, *Ae. aegypti* and *An. stephensi* and the results are presented in Tables 4.1 to 4.18.

4.1.1 *Albizia lebbeck*

Larvicidal response of *A. lebbeck* leaf and seed extracts of the three species mosquito larvae are presented in Tables 4.1 to 4.6.

4.1.1.1 Larvicidal activity of *A. lebbeck* against *Cx. quinquefasciatus*

The larvicidal activity of different solvent leaf and seed extracts of *A. lebbeck* against the vector mosquito *Cx. quinquefasciatus* is presented in Table 4.1 and 4.2. The results revealed that the leaf methanol extract had the significant larvicidal activity with LC$_{50}$ and LC$_{90}$ values of 68.98 ppm and 125.94 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate larvicidal activity with the LC$_{50}$ and LC$_{90}$ values were 76.53, 90.21, 96.16, 101.07 ppm and 130.56, 161.65, 167.32, 172.07 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 114.15 and 219.76 ppm observed in the methanol extract and the higher values of 125.87, 139.54, 150.96, 160.83 and 240.43, 260.16, 277.48, 290.38 ppm observed in the ethyl acetate, chloroform, benzene, and hexane extract against *Cx. quinquefasciatus*, respectively.
4.1.1.2 Larvicidal activity of *A. lebbeck* against *Ae. aegypti*

The larvicidal activity of different solvent extracts of *A. lebbeck* leaf and seed against vector mosquito *Ae. aegypti* is presented in Table 4.3 and 4.4. The results revealed that the methanol extract had the significant larvicidal activity with LC$_{50}$ and LC$_{90}$ values of 47.66 ppm and 82.04 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate larvicidal activity with the LC$_{50}$ and LC$_{90}$ values were 55.66, 60.02, 67.36, 72.35 ppm and 99.55, 104.21, 121.17, 126.09 ppm, respectively. The chi-square values were significant at $p<0.05$ level.

Seed extracts have moderate larvicidal activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 90.74 and 178.15 ppm observed in the methanol extract and the higher values of 101.29, 109.93, 116.91, 123.69 and 198.42, 211.40, 212.74, 223.35 ppm observed in the ethyl acetate, chloroform, benzene, and hexane extract against *Ae. aegypti*, respectively.

4.1.1.3 Larvicidal activity of *A. lebbeck* against *An. stephensi*

The larvicidal activity of different solvent extracts of *A. lebbeck* leaf and seed against vector mosquito *An. stephensi* is presented in Table 4.5 and 4.6. Among the tested solvents methanol showed highest larvicidal activity followed by ethyl acetate, chloroform, benzene, and hexane extracts. The LC$_{50}$ and LC$_{90}$ values the methanol extract were 34.71 ppm and 60.72 ppm, respectively. The LC$_{50}$ and LC$_{90}$ values of other extracts of ethyl acetate, chloroform, benzene, and hexane were 39.02, 45.52, 48.92, 57.62 ppm and 76.84, 81.29, 84.53, 102.05 ppm, respectively. The chi-square values were significant at $p<0.05$ level.
Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 48.99 and 96.75 ppm observed in the methanol extract and the higher values of 58.78, 66.95, 72.65, 77.94 and 114.48, 127.05, 132.79, 140.20 ppm observed in the ethyl acetate, chloroform, benzene, and hexane extract against *An. stephensi*, respectively.

### 4.1.2 Delonix elata

Larvicidal response of *D. elata* leaf and seed extracts of the three species mosquito larvae are presented in Tables 4.7 to 4.12.

#### 4.1.2.1 Larvicidal activity of *D. elata* against *Cx. quinquefasciatus*

The larvicidal activity of different solvent extracts of *D. elata* leaf and seed against vector mosquito *Cx. quinquefasciatus* is presented in Table 4.7 and 4.8. The methanol extract of *D. elata* registered as most potent larvicides among the five extracts evaluated with the LC$_{50}$ and LC$_{90}$ values of 124.84 and 213.88 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate larvicidal activity with the LC$_{50}$ and LC$_{90}$ values were 130.55, 135.93, 144.58, 160.91 ppm and 238.43, 243.16, 251.39, 290.22 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 147.86 and 289.43 ppm observed in methanol extract and the higher values of 178.79, 201.89, 220.99, 235.23 and 343.71, 390.27, 416.93, 429.06 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against *Cx. quinquefasciatus*, respectively.
4.1.2.2 Larvicidal activity of *D. elata* against *Ae. aegypti*

The larvicidal activity of different solvent extracts of *D. elata* leaf and seed against vector mosquito *Ae. aegypti* is presented in Table 4.9 and 4.10. The effect of different extracts of *D. elata* against *Ae. aegypti* revealed that the highest larval mortality was observed in methanol and lowest larval mortality was observed in hexane extract of *D. elata* with LC$_{50}$ and LC$_{90}$ values of 111.83, 150.98 ppm and 202.77, 256.28 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene was showed moderate larvicidal activity with the LC$_{50}$ and LC$_{90}$ values were 118.44, 138.14, 142.56 ppm and 211.18, 247.53, 250.67 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 139.04 and 273.03 ppm observed in methanol extract and the higher values of 164.73, 185.33, 206.32, 221.09 and 319.83, 352.70, 380.29, 398.40 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against *Ae. aegypti*, respectively.

4.1.2.3 Larvicidal activity of *D. elata* against *An. stephensi*

The larvicidal activity of different solvent extracts of *D. elata* leaf and seed against vector mosquito *An. stephensi* is presented in Table 4.11 and 4.12. The results revealed that the methanol extract had the significant larvicidal activity with LC$_{50}$ and LC$_{90}$ values of 93.59 ppm and 163.69 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate larvicidal activity with the LC$_{50}$ and LC$_{90}$ values were 112.13, 118.26, 126.03, 137.23 ppm and 201.49, 207.58, 216.19, 245.71 ppm, respectively. The chi-square values were significant at p<0.05 level.
Seed extracts have moderate activity against tested mosquitoes. The lowest LC\textsubscript{50} and LC\textsubscript{90} values of 115.28 and 225.07 ppm observed in methanol extract and the higher values of 150.02, 162.26, 172.92, 188.45 and 292.14, 310.43, 326.41, 344.82 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against \textit{An. stephensi}, respectively.

### 4.1.3 \textit{Pithecellobium dulce}

Larvicidal response of \textit{P. dulce} leaf and seed extracts of the three species mosquito larvae are presented in Tables 4.13 to 4.18.

#### 4.1.3.1 Larvicidal activity of \textit{P. dulce} against \textit{Cx. quinquefasciatus}

The larvicidal activity of different solvent extracts of \textit{P. dulce} leaf and seed against vector mosquito \textit{Cx. quinquefasciatus} is presented in Table 4.13 and 4.14. Out of five extracts tested, the methanol extract found to be effective against the larvae of \textit{Cx. quinquefasciatus} which is followed by the ethyl acetate, chloroform, benzene, and hexane extracts with the LC\textsubscript{50} and LC\textsubscript{90} values were 164.12, 170.66, 175.38, 184.96, 197.23 ppm and 289.34, 301.91, 309.07, 331.42, 348.34 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC\textsubscript{50} and LC\textsubscript{90} values of 214.2 and 410.18 ppm observed in methanol extract and the higher LC\textsubscript{50} and LC\textsubscript{90} values of 240.37, 274.74, 303.22, 322.80 and 467.04, 526.81, 565.86, 587.89 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against \textit{Cx. quinquefasciatus}, respectively.
4.1.3.2 Larvicidal activity of *P. dulce* against *Ae. aegypti*

The larvicidal activity of different solvent extracts of *P. dulce* leaf and seed against vector mosquito *Ae. aegypti* is presented in Table 4.15 and 4.16. The results revealed that the methanol extract had the significant larvicidal activity with LC$_{50}$ and LC$_{90}$ values of 155.78 ppm and 279.73 ppm, respectively. The other extracts of in ethyl acetate, chloroform, benzene, and hexane was showed moderate larvicidal activity with the LC$_{50}$ and LC$_{90}$ values were 162.36, 169.08, 176.02, 185.14 ppm and 283.43, 293.17, 308.88, 316.46 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 193.66 and 377.39 ppm observed in methanol extract and the higher LC$_{50}$ and LC$_{90}$ values of 215.63, 240.39, 259.42, 281.18 and 416.51, 461.28, 489.41, 516.33 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against *Ae. aegypti*, respectively.

4.1.3.3 Larvicidal activity of *P. dulce* against *An. stephensi*

The larvicidal activity of different solvent extracts of *P. dulce* leaf and seed against vector mosquito *An. stephensi* is presented in Table 4.17 and 4.18. The toxicity of the five different extracts of (methanol, ethyl acetate, chloroform, benzene, and hexane) *P. dulce* against *An. stephensi* showed significant larvicidal activity. Their LC$_{50}$ and LC$_{90}$ values were 145.43, 153.41, 160.71, 166.96, 172.82 ppm and 251.23, 275.87, 282.35, 290.40, 307.50 ppm, respectively. The maximum efficacy was observed in methanol extract and the minimum efficacy in the hexane extract.
Seed extracts have moderate activity against tested mosquitoes. The lowest LC\textsubscript{50} and LC\textsubscript{90} values of 168.32, and 315.42 ppm observed in methanol extract and the higher LC\textsubscript{50} and LC\textsubscript{90} values of 185.19, 199.39, 241.19, 263.09 and 362.12, 381.10, 444.77, 478.47 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against \textit{An. stephensi}, respectively.

Among the three plant leaf and seed extracts tested against the larvae of \textit{An. stephensi}, \textit{Ae. aegypti} and \textit{Cx. quinquefasciatus} the larvae of \textit{An. stephensi} were more susceptible than the larvae of \textit{Ae. aegypti} and \textit{Cx. quinquefasciatus}. The highest larvicidal efficacy was noticed in methanol extract of \textit{A. lebbeck} leaf (34.71 ppm), followed by methanol extract of \textit{D. elata} (93.59 ppm), and methanol extract of \textit{P. dulce} (145.43 ppm). All the three plant species showed the LC\textsubscript{50} values below 175 ppm, ranged from 34.71 to 172.82 ppm against \textit{An. stephensi}. The larvicidal activity of \textit{Cx. quinquefasciatus} with these plant species exerted the LC\textsubscript{50} values ranged from 68.98 to 197.23 ppm whereas the dengue fever mosquito \textit{Ae. aegypti} indicated the LC\textsubscript{50} values ranged from 47.66 to 185.14 ppm, among the three plants tested against three mosquito species, the plant species \textit{A. lebbeck} exerted the low LC\textsubscript{50} values. The above results concluded that among the three plant species, \textit{A. lebbeck} acts as a potential for all the three mosquito species namely \textit{An. stephensi}, \textit{Ae. aegypti} and \textit{Cx. quinquefasciatus}.

4.2 Ovicidal activity of three plants crude extracts against vector mosquitoes

4.2.1 \textit{Albizia lebbeck}

The percentage of egg hatchability of \textit{Cx. quinquefasciatus}, \textit{Ae. aegypti} and \textit{An. stephensi} with the leaf and seed crude extract of \textit{A. lebbeck} are presented in Table 4.19 and 4.20.
4.2.1.1 Ovicidal activity of *A. lebbeck* against *Cx. quinquefasciatus*

Among the five solvents tested against *Cx. quinquefasciatus* the methanol extract exerted significant ovicidal activity. 100 percent mortality (Zero hatchability) was observed at 250 and 375 ppm in leaf and seed extracts, respectively. Control eggs showed 100 percent hatchability.

4.2.1.2 Ovicidal activity of *A. lebbeck* against *Ae. aegypti*

The eggs of *Ae. aegypti* in the control group showed the egg hatchability of 100 percent. The methanol extract was more toxic to the eggs of *Ae. aegypti* and exhibited 100 percent mortality at 200 and 300ppm in leaf and seed extracts, respectively.

4.2.1.3 Ovicidal activity of *A. lebbeck* against *An. stephensi*

There was zero hatchability (100 percent mortality) was attained at the concentration of 150 and 225 ppm in leaf and seed methanol extract, followed by extracts of ethyl acetate, chloroform, benzene and hexane. Control eggs showed 100 percent hatchability.

The rate of hatchability was higher in lower concentrations and when concentrations of the extracts increased the hatchability rate decreased. These results clearly revealed that the toxicity of leaf and seed extracts was dependent on its concentration and which will determine the egg hatchability. Eggs of *An. stephensi* and *Ae. aegypti* were more susceptible to the leaf and seed extracts of *A. lebbeck* than *Cx. quinquefasciatus*. 
4.2.2 *Delonix elata*

The effect of *D. elata* leaf and seed extracts on the egg hatchability of *Cx. quinquefasciatus*, *Ae. aegypti* and *An. stephensi* are presented in Table 4.21 and 4.22.

4.2.2.1 Ovicidal activity of *D. elata* against *Cx. quinquefasciatus*

The ovicidal activity of *D. elata* against *Cx. quinquefasciatus* revealed that there was 100 percent hatchability in all control groups. The methanol and ethyl acetate extract were notable, which attained the 100 percent mortality at the concentration of 375 ppm in leaf extract and 600 ppm in seed extract.

4.2.2.2 Ovicidal activity of *D. elata* against *Ae. aegypti*

The methanol extract of *D. elata* was show significant result against *Ae. aegypti* eggs. The zero hatchability (100 percent mortality) was attained at the concentration of 300 ppm in leaf extract and 500 ppm in seed methanol extract. The hatchability rate of control group is 100 percent.

4.2.2.3 Ovicidal activity of *D. elata* against *An. stephensi*

Methanol and ethyl acetate extract was produced higher toxicity of *An. stephensi* eggs. Leaf and seed methanol extract of *D. elata* was produce 100 percent mortality at 300 and 500 ppm, respectively. Control eggs exerted 100 percent hatchability.

4.2.3 *Pithecellobium dulce*

Ovicidal activity of *P. dulce* against the three vector mosquitoes are presented in Table 4.23 and 4.24.
4.2.3.1 Ovicidal activity of *P. dulce* against *Cx. quinquefasciatus*

Methanol extract was produce promising results against egg rafts of *Cx. quinquefasciatus*. 100 percent mortality was observed when the eggs are exposed at the concentration of 500 and 750 ppm in leaf and seed extracts, respectively. The eggs in control groups exerted the 100 percent hatchability.

4.2.3.2 Ovicidal activity of *P. dulce* against *Ae. aegypti*

The percent hatchability of eggs in control was 100 percent with different extracts. Compared to other solvents, methanol was produced better result. The 100 percent mortality was observed at the concentration of 400 and 625 ppm in leaf and seed extracts, respectively.

4.2.3.3 Ovicidal activity of *P. dulce* against *An. stephensi*

Methanol and ethyl acetate extract was produced higher toxicity of *An. stephensi* eggs. Leaf and seed methanol extract of *P. dulce* was produce 100 percent mortality at 400 and 500 ppm, respectively. Control eggs exerted 100 percent hatchability.

The three plant species evaluated for ovicidal activity against the vector mosquitoes *viz.*, *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* the methanol extract of *A. lebbeck* leaf exerted 100 percent mortality at 150 ppm against *An. stephensi* and 100 percent mortality was showed at 200 ppm against *Ae. aegypti* and 250 ppm against *Cx. quinquefasciatus*. The plant species *D. elata* leaf showed zero hatchability at 300 ppm (methanol and ethyl acetate) against *An. stephensi* and *Ae. aegypti*. Methanol and ethyl acetate extracts of *P. dulce* leaf exhibited complete ovicidal activity at 400 ppm against *An. stephensi* and *Ae. aegypti*. The above results concluded that among the three
plant species, *A. lebbeck* acts as a potential for ovicidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus*.

4.3 Adulticidal activity of crude extracts

Adulticidal activity of three plant leaf and seed extracts with five different solvents was tested against the adult of three important vector mosquitoes *viz.*, *Cx. quinquefasciatus*, *Ae. aegypti* and *An. stephensi* and the results are presented in Tables 4.25 to 4.42.

4.3.1 *Albizia lebbeck*

Adulticidal activity of *A. lebbeck* leaf and seed extracts of the three species of adult mosquitoes are presented in Tables 4.25 to 4.30.

4.3.1.1 Adulticidal activity of *A. lebbeck* against *Cx. quinquefasciatus*

The adulticidal activity of different solvent extracts of *A. lebbeck* leaf and seed against vector mosquito *Cx. quinquefasciatus* is presented in Table 4.25 and 4.26. The results revealed that the methanol extract had the significant adulticidal activity with LC$_{50}$ and LC$_{90}$ values of 92.17 ppm and 164.89 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate adulticidal activity with the LC$_{50}$ and LC$_{90}$ values were 112.24, 129.20, 138.76, 148.86 ppm and 200.81, 236.58, 246.52, 259.58 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 145.53 and 285.73 ppm observed in methanol extract and the higher values of 172.01, 193.03, 210.04, 231.59 ppm and 330.93, 362.56, 385.05, 414.80 ppm
observed in ethyl acetate, chloroform, benzene, and hexane extract against *Cx. quinquefasciatus*, respectively.

### 4.3.1.2 Adulticidal activity of *A. lebbeck* against *Ae. aegypti*

The adulticidal activity of different solvent extracts of *A. lebbeck* leaf and seed against vector mosquito *Ae. aegypti* is presented in Table 4.27 and 4.28. The results revealed that the methanol extract had the significant adulticidal activity with LC$_{50}$ and LC$_{90}$ values of 69.69 ppm and 123.98 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate adulticidal activity with the LC$_{50}$ and LC$_{90}$ values were 87.74, 99.67, 111.65, 119.22 ppm and 157.93, 173.06, 203.52, 210.77 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 125.51 and 243.26 ppm observed in methanol extract and the higher values of 146.64, 162.74, 173.87, 193.30 ppm and 287.54, 310.96, 323.84, 350.37 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against *Ae. aegypti*, respectively.

### 4.3.1.3 Adulticidal activity of *A. lebbeck* against *An. stephensi*

The adulticidal activity of different solvent extracts of *A. lebbeck* leaf and seed against vector mosquito *An. stephensi* is presented in Table 4.29 and 4.30. Among the tested solvents methanol showed highest adulticidal activity followed by ethyl acetate, chloroform, benzene, and hexane extracts. The LC$_{50}$ and LC$_{90}$ values the methanol extract were of 65.12 ppm and 117.70 ppm, respectively. The LC$_{50}$ and LC$_{90}$ values of other extracts of ethyl acetate, chloroform, benzene, and hexane were 74.11, 85.73,
97.56, 105.37 ppm and 129.46, 163.50, 170.31, 182.03 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC50 and LC90 values of 104.72 and 204.51 ppm observed in methanol extract and the higher values of 118.97, 131.64, 144.49, 156.45 ppm and 228.98, 244.09, 263.09, 281.29 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against An. stephensi, respectively.

4.3.2 Delonix elata

Adulticidal response of D. elata leaf and seed extracts of the three species mosquito adults are presented in Tables 4.31 to 4.36.

4.3.2.1 Adulticidal activity of D. elata against Cx. quinquefasciatus

The adulticidal activity of different solvent extracts of D. elata leaf and seed against vector mosquito Cx. quinquefasciatus is presented in Table 4.31 and 4.32. The methanol extract of D. elata registered as most potent adulticidal among the five extracts evaluated with the LC50 and LC90 values of 197.28 and 347.45 ppm, the other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate adulticidal activity with the LC50 and LC90 values were 209.08, 225.43, 241.33, 265.97 ppm and 385.10, 416.97, 433.80, 487.19 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC50 and LC90 values of 253.61 and 471.53 ppm observed in methanol extract and the higher values of 270.76, 289.95, 310.56, 330.98 ppm and 500.00, 532.77, 565.87, 597.20 ppm
observed in ethyl acetate, chloroform, benzene, and hexane extract against *Cx. quinquefasciatus*, respectively.

### 4.3.2.2 Adulticidal activity of *D. elata* against *Ae. aegypti*

The adulticidal activity of different solvent extracts of *D. elata* leaf and seed against vector mosquito *Ae. aegypti* is presented in Table 4.33 and 4.34. The effect of different extracts of *D. elata* against *Ae. aegypti* revealed that the highest adult mortality was observed in methanol and lowest adult mortality was observed in hexane extract of *D. elata* with LC$_{50}$ and LC$_{90}$ values of 162.87, 223.58 ppm and 309.32, 401.45 ppm, respectively. The other extracts of ethyl acetate, chloroform and benzene was showed moderate adulticidal activity with the LC$_{50}$ and LC$_{90}$ values were 178.89, 190.41, 203.03 ppm and 316.27, 345.70, 357.33 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 199.86 and 387.70 ppm observed in methanol extract and the higher values of 220.35, 237.34, 255.46, 277.47 ppm and 415.98, 448.95, 480.01, 507.53 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against *Ae. aegypti*, respectively.

### 4.3.2.3 Adulticidal activity of *D. elata* against *An. stephensi*

The adulticidal activity of different solvent extracts of *D. elata* leaf and seed against vector mosquito *An. stephensi* is presented in Table 4.35 and 4.36. The results revealed that the methanol extract had the significant adulticidal activity with LC$_{50}$ and LC$_{90}$ values of 137.33 ppm and 259.88 ppm, respectively. The other extracts of ethyl
acetate, chloroform, benzene, and hexane was showed moderate adulticidal activity with the LC$_{50}$ and LC$_{90}$ values were 152.57, 168.26, 184.71, 203.74 ppm and 276.82, 313.07, 343.98, 368.95 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 178.14 and 352.13 ppm observed in methanol extract and the higher values of 198.91, 214.69, 236.24, 259.23 ppm and 383.12, 421.23, 455.00, 480.98 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against An. stephensi, respectively.

4.3.3 Pithecellobium dulce

Adulticidal activity of P. dulce leaf and seed extracts of the three species of adult mosquitoes are presented in Tables 4.37 to 4.42.

4.3.3.1 Adulticidal activity of P. dulce against Cx. quinquefasciatus

The adulticidal activity of different solvent extracts of P. dulce leaf and seed against vector mosquito Cx. quinquefasciatus is presented in Table 4.37 and 4.38. Out of five extracts tested, the methanol extract found to be effective against the adult of Cx. quinquefasciatus which is followed by the ethyl acetate, chloroform, benzene and hexane extracts with the LC$_{50}$ and LC$_{90}$ values were 234.97, 269.41, 296.06, 323.21, 356.57 ppm and 464.86, 511.16, 566.21, 609.73, 664.31 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 309.24 and 570.80 ppm observed in methanol extract and the higher values of 334.50, 362.77, 392.58, 416.79 ppm and 618.74, 667.44, 720.17, 746.55 ppm
observed in ethyl acetate, chloroform, benzene, and hexane extract against *Cx. quinquefasciatus*, respectively.

### 4.3.3.2 Adulticidal activity of *P. dulce* against *Ae. aegypti*

The adulticidal activity of different solvent extracts of *P. dulce* leaf and seed against vector mosquito *Ae. aegypti* is presented in Table 4.39 and 4.40. The results revealed that the methanol extract had the significant adulticidal activity with LC$_{50}$ and LC$_{90}$ values of 218.64 ppm and 426.05 ppm, respectively. The other extracts of ethyl acetate, chloroform, benzene, and hexane was showed moderate adulticidal activity with the LC$_{50}$ and LC$_{90}$ values were 237.86, 259.98, 282.43, 311.07 ppm and 448.95, 486.86, 526.63, 571.55 ppm, respectively. The chi-square values were significant at p<0.05 level.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 257.99 and 507.73 ppm observed in methanol extract and the higher values of 304.96, 331.42, 363.48, 393.62 ppm and 594.12, 630.05, 676.85, 699.08 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against *Ae. aegypti*, respectively.

### 4.3.3.3 Adulticidal activity of *P. dulce* against *An. stephensi*

The adulticidal activity of different solvent extracts of *P. dulce* leaf and seed against vector mosquito *An. stephensi* is presented in Table 4.41 and 4.42. The toxicity of the five different extracts of (methanol, ethyl acetate, chloroform, benzene, and hexane) *P. dulce* against *An. stephensi* showed significant adulticidal activity. Their LC$_{50}$ and LC$_{90}$ values were 197.91, 216.33, 233.05, 254.23, 273.45 ppm and 372.27, 393.77,
419.66, 455.19, 493.62 ppm, respectively. The maximum efficacy was observed in methanol extract and the minimum efficacy in the hexane extract.

Seed extracts have moderate activity against tested mosquitoes. The lowest LC$_{50}$ and LC$_{90}$ values of 237.57 and 470.34 ppm observed in methanol extract and the higher values of 275.69, 315.85, 336.63, 363.68 and 516.47, 603.50, 631.21, 648.71 ppm observed in ethyl acetate, chloroform, benzene, and hexane extract against *An. stephensi*, respectively.

Among the three plant extracts tested against the adult of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* the adults of *An. stephensi* were more susceptible than the adults of *Ae. aegypti* and *Cx. quinquefasciatus*. The highest adulticidal efficacy was noticed in methanol extract of *A. lebbeck* leaf (65.12 ppm), followed by methanol extract of *D. elata* leaf (137.33 ppm), methanol extract of *P. dulce* leaf (197.91 ppm). All the three plant species showed the LC$_{50}$ values ranged from 65.12 to 273.45 ppm against *An. stephensi*.

The adulticidal activity of filariasis vector, *Cx. quinquefasciatus* with these plant species exerted the LC$_{50}$ values ranged from 92.17 to 356.57 ppm whereas the dengue fever mosquito *Ae. aegypti* indicated the LC$_{50}$ values ranged from 69.69 to 311.07 ppm, among the three plants tested against three mosquito species, the plant species *A. lebbeck* exerted the low LC$_{50}$ values followed by *D. elata* and *P. dulce*. The above results concluded that among the three plant species, *A. lebbeck* acts as a potential for all the three mosquito species namely *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus*. 
4.4 Laboratory skin repellent test

Each plant crude extracts tested for their skin repellent activity with three different concentration (1.0, 2.5 and 5.0mg/cm$^2$) against three different mosquitoes viz., *Cx. quinquefasciatus*, *Ae. aegypti* and *An. stephensi* in laboratory condition with different exposure time. It shows that the repellency depends on the strength of the plant extracts. Repellency (as shown in percentage of protection) obtained for different exposure time for each plant crude extracts repellent and assessed mean protection time (±SD) against three mosquito species. These results are presented in table 4.43 to 4.60.

4.4.1 *Albizia lebbeck*

Repellent activity of different solvent crude extracts of *A. lebbeck* leaf and seed against *Cx. quinquefasciatus*, *Ae. aegypti*, and *An. stephensi* are presented in Tables 4.43 to 4.48.

4.4.1.1 Repellent activity of *A. lebbeck* against *Cx. quinquefasciatus*

The skin repellent activity of different solvent extracts of *A. lebbeck* leaf and seed against *Cx. quinquefasciatus* was presented in Table 4.43 and 4.44. When the repellent activity of three different concentrations were compared (1.0, 2.5 and 5.0 mg/cm$^2$) on volunteer skin (fore arm), the results revealed that the protection observed at 5.0 mg/cm$^2$ concentration was more than other two concentrations. The leaf extract was more protection than seed. Among the tested solvents methanol extract provided significant repellency against *Cx. quinquefasciatus*. The higher concentration of 5.0 mg/cm$^2$ provides 100% protection up to 210 minutes. The lower concentration of 2.5 and 1.0 mg/cm$^2$ provided 100% protection up to 180 and 150 minutes, respectively. The other
solvents *viz.*, ethyl acetate, chloroform showed that 100% protection upto 180 minutes. Benzene and hexane showed that 100% protection upto 150 minutes at the higher concentration of 5.0 mg/cm$^2$.

The seed methanol extract at the higher concentration of 5.0 mg/cm$^2$ provided 100% protection up to 180 minutes. The lower concentration of 2.5 and 1.0 mg/cm$^2$ provided 100% protection up to 150 and 120 minutes, respectively. The other solvents *viz.*, ethyl acetate, chloroform and benzene showed that 100% protection upto 150 minutes at the higher concentration of 5.0 mg/cm$^2$.

**4.4.1.2 Repellent activity of *A. lebbeck* against *Ae. aegypti***

The skin repellent activity of different solvent extracts of *A. lebbeck* (leaf and seed) against *Ae. aegypti* was presented in Table 4.45 and 4.46. It was observed that *A. lebbeck* leaf extracts exhibited better protection against the bites of *Ae. aegypti* mosquitoes in methanol extract than other four extracts. The maximum protection 240 minutes was observed that the higher concentration 5.0 mg/cm$^2$ methanol extract of *A. lebbeck*. The lower concentrations of 2.5 and 1.0 mg/cm$^2$ provided 100% protection up to 210 to 180 minutes, respectively. The other solvents *viz.*, ethyl acetate, chloroform and benzene showed that 100% protection up to 210 minutes and hexane showed that 100% protection upto 180 minutes at the higher concentration of 5.0 mg/cm$^2$.

The seed methanol extract at the higher concentration of 5.0 mg/cm$^2$ provided 100% protection up to 210 minutes. The lower concentration of 2.5 and 1.0 mg/cm$^2$ provided 100% protection up to 180 minutes. The other solvents *viz.*, ethyl acetate and chloroform showed that 100% protection up to 180 minutes. Benzene and hexane showed that 100% protection upto 150 minutes at the higher concentration of 5.0 mg/cm$^2$. 
**4.4.1.3 Repellent activity of *A. lebbeck* against *An. stephensi***

The skin repellent activity of different solvent extracts of *A. lebbeck* leaf and seed against *An. stephensi* was presented in Table 4.47 and 4.48. From this study it was found that among the five extracts of *A. lebbeck* (leaf) the methanol extract was found to be more effective (270 minutes) than other extracts when applied at the rate of 5.0 mg/cm\(^2\) concentration on volunteer skin. The lower concentration of 2.5 and 1.0 mg/cm\(^2\) methanol extract provided 100% protection up to 240 and 210 minutes, respectively. The other solvents *viz.*, ethyl acetate and chloroform showed that 100% protection up to 240 minutes; benzene and hexane showed that 100% protection up to 210 minutes at the higher concentration of 5.0 mg/cm\(^2\).

The seed methanol extract at the higher concentration of 5.0 mg/cm\(^2\) provided 100% protection up to 240 minutes. The lower concentration of 2.5 and 1.0 mg/cm\(^2\) provided 100% protection up to 210 and 180 minutes, respectively. The other solvents *viz.*, chloroform, benzene and hexane showed that 100% protection up to 180 minutes and the ethyl acetate showed that 100% protection up to 210 minutes at the higher concentration of 5.0 mg/cm\(^2\).

**4.4.2 *Delonix elata***

Repellent activity of different solvent crude extract of *D. elata* leaf and seed against *Cx. quinquefasciatus*, *Ae. aegypti*, and *An. stephensi* are presented in Tables 4.49 to 4.54.
4.4.2.1 Repellent activity of *D. elata* against *Cx. quinquefasciatus*

The skin repellent activity of different solvent extracts of *D. elata* (leaf and seed) against *Cx. quinquefasciatus* was presented in Table 4.49 and 4.50. The highest percent protection for all the extracts of *D. elata* was observed at 5.0 mg/cm$^2$ concentration followed by 2.5 and 1.0 mg/cm$^2$ concentrations. Leaf methanol extract produce 150 minutes protection at the higher concentrations of 5.0 mg/cm$^2$. The other solvents *viz.*, ethyl acetate, chloroform and benzene showed that 100% protection up to 120 minutes and hexane showed that 100% protection up to 90 minutes at the higher concentration of 5.0 mg/cm$^2$. In the lower concentration of 1.0 mg/cm$^2$, except methanol all other solvents show 100 percent protection upto 60 minutes.

The seed methanol extract at the higher concentration of 5.0 mg/cm$^2$ provided 100 % protection up to 120 minutes. The lower concentration of 2.5 and 1.0 mg/cm$^2$ provided 100% protection up to 90 minutes. The other four solvents showed that 100% protection up to 90 minutes at the higher concentration of 5.0 mg/cm$^2$.

4.4.2.2 Repellent activity of *D. elata* against *Ae. aegypti*

The skin repellent activity of different solvent extracts of *D. elata* (leaf and seed) against *Ae. aegypti* was presented in Table 4.51 and 4.52. Leaf methanol extract produce 180 minutes protection at the higher concentrations of 5.0 mg/cm$^2$. Ethyl acetate and chloroform extract produce 150 minutes protection at the higher concentrations of 5.0 mg/cm$^2$. Benzene and hexane extract produce 120 minutes protection at the higher concentrations of 5.0 mg/cm$^2$. 
The seed methanol extract at the higher concentration of 5.0 mg/cm² provided 100% protection up to 150 minutes. The lower concentration of 2.5 and 1.0 mg/cm² provided 100% protection up to 120 and 90 minutes, respectively. In the higher concentration of 5.0 mg/cm², except ethyl acetate all other solvents show 100 percent protection up to 90 minutes.

### 4.4.2.3 Repellent activity of *D. elata* against *An. stephensi*

The skin repellent activity of different solvent extracts of *D. elata* (leaf and seed) against *An. stephensi* was presented in Table 4.53 and 4.54. The highest percent protection for all the extracts of *D. elata* was observed at 5.0 mg/cm² concentration followed by 2.5 and 1.0 mg/cm² concentrations. Leaf methanol extract produce 210 minutes protection at the higher concentrations of 5.0 mg/cm². Ethyl acetate and chloroform showed the protection of 180 minutes, benzene and hexane showed the protection of 150 minutes at the higher concentrations of 5.0 mg/cm².

The seed methanol extract at the higher concentration of 5.0 mg/cm² provided 100% protection up to 180 minutes. The lower concentration of 2.5 and 1.0 mg/cm² provided 100% protection up to 150 and 120 minutes, respectively. In the lower concentration of 1.0 mg/cm², except methanol and ethyl acetate all other solvents show 100 percent protection up to 90 minutes.

### 4.4.3 *Pithecellobium dulce*

Repellent activity of different solvent crude extract of *P. dulce* leaf and seed against *Cx. quinquefasciatus, Ae. aegypti* and *An. stephensi* presented in Tables 4.55 to 4.60.
4.4.3.1 Repellent activity of *P. dulce* against *Cx. quinquefasciatus*

The skin repellent activity of different solvent extracts of *A. lebbeck* leaf and seed against *Cx. quinquefasciatus* was presented in Table 4.55 and 4.56. When the repellent activity of three different concentrations were compared (1.0, 2.5 and 5.0 mg/cm²) on volunteer skin (fore arm), the results revealed that the protection observed at 5.0 mg/cm² concentration was more than other two concentrations. The leaf extract was more protection than seed. Among the tested solvents methanol extract provided significant repellency against *Cx. quinquefasciatus*. The higher concentration of 5.0 mg/cm² provides 100% protection up to 120 minutes. The lower concentration of 2.5 and 1.0 mg/cm² provided 100% protection up to 90 minutes. The other solvents *viz.*, ethyl acetate and chloroform showed that 100% protection upto 90 minutes. Benzene and hexane showed that 100% protection upto 60 minutes at the higher concentration of 5.0 mg/cm².

The seed methanol extract at the higher concentration of 5.0 mg/cm² provided 100% protection up to 90 minutes. The lower concentration of 2.5 and 1.0 mg/cm² provided 100% protection up to 60 minutes. The other four solvents showed that 100% protection upto 60 minutes at the higher concentration of 5.0 mg/cm².

4.4.3.2 Repellent activity of *P. dulce* against *Ae. aegypti*

The skin repellent activity of different solvent extracts of *P. dulce* (leaf and seed) against *Ae. aegypti* was presented in Table 4.57 and 4.58. Leaf methanol extract produce 150 minutes protection at the higher concentrations of 5.0 mg/cm². Ethyl acetate and chloroform extract produce 120 minutes protection at the higher concentrations of 5.0 mg/cm². Benzene and hexane extract produce 90 minutes protection at the higher concentrations of 5.0 mg/cm².
The seed methanol extract at the higher concentration of 5.0 mg/cm$^2$ provided 100% protection up to 120 minutes. The lower concentration of 2.5 and 1.0 mg/cm$^2$ provided 100% protection up to 90 and 60 minutes, respectively. In the lower concentration of 1.0 mg/cm$^2$, except ethyl acetate all other solvents show 100 percent protection up to 30 minutes.

4.4.3.3 Repellent activity of $P.$ dulce against An. stephensi

The skin repellent activity of different solvent extracts of $A.$ lebbeck leaf and seed against An. stephensi was presented in Table 4.59 and 4.60. From this study it was found that among the five extracts of $A.$ lebbeck leaf methanol extract was found to be more effective (180 minutes) than other extracts when applied at the rate of 5.0 mg/cm$^2$ concentration on volunteer skin. The lower concentration of 2.5 and 1.0 mg/cm$^2$ methanol extract provided 100% protection up to 150 and 120 minutes, respectively. The other solvents viz., ethyl acetate, chloroform and benzene showed that 100% protection up to 150 minutes; hexane showed that 100% protection up to 120 minutes at the higher concentration of 5.0 mg/cm$^2$.

The seed methanol extract at the higher concentration of 5.0 mg/cm$^2$ provided 100% protection up to 150 minutes. The lower concentration of 2.5 and 1.0 mg/cm$^2$ provided 100% protection up to 120 and 90 minutes, respectively. The other solvents viz., chloroform, benzene and hexane showed that 100% protection up to 120 minutes and the ethyl acetate showed that 100% protection up to 150 minutes at the higher concentration of 5.0 mg/cm$^2$.

Among the three plants leaf and seed tested for repellent activity against Cx. quinquefasciatus, Ae. aegypti and An. stephensi, the plant species $A.$ lebbeck leaf
afforded the maximum protection for *An. stephensi* followed by *Ae. aegypti* and *Cx. quinquefasciatus*. Whereas the other plant species namely *D. elata* and *P. dulce* afforded the maximum protection for *An. stephensi* followed by *Ae. aegypti* and *Cx. quinquefasciatus*. The plant species *A. lebbeck* showed the mean protection upto 270 minutes, *D. elata* showed the upto 210 minutes, *P. dulce* showed the upto 180 minutes at the concentration of 5.0 mg/cm$^2$ against *An. stephensi*.

4.5 Identification of mosquitocidal compound from *A. lebbeck*

After the isolation of single pure mosquitocidal compound from the leaf extract of *A. lebbeck* it was subjected to $^1$H NMR, $^{13}$C NMR, IR, UV and GC-MS spectral analysis for the identification of functional group, molecular formula and molecular weight of the compound (Fig 4.1 to 4.5).

4.5.1 Spectral analysis of the Compound

The $^1$H NMR spectrum of the compound showed the presence of -CH=CH-, m (7.87), -CH$_2$-, T (3.40), -CH$_2$-, m (2.52), -CH$_2$, m (1.31) and CH$_3$-, t (0.82) groups.

The $^{13}$C NMR spectrum of compound showed the presence of =C–OH (176.8), -CH=CH- (126.02), -CH$_2$ - (40.4), -CH$_2$-, (37.6) and -CH$_2$-, (35.73) groups.

The infrared spectrum of compound showed the peaks at 3407 Cm$^{-1}$, 1665 Cm$^{-1}$, 1611 Cm$^{-1}$, 1562 Cm$^{-1}$, 1523 Cm$^{-1}$, 1466 Cm$^{-1}$, 1452 Cm$^{-1}$, 1382 Cm$^{-1}$, 1320 Cm$^{-1}$, 1262 Cm$^{-1}$, 1200 Cm$^{-1}$, 1169 Cm$^{-1}$, 1125 Cm$^{-1}$, 1089 Cm$^{-1}$, 1009 Cm$^{-1}$, 943 Cm$^{-1}$, 861 Cm$^{-1}$, 823 Cm$^{-1}$, 716 Cm$^{-1}$, 666 Cm$^{-1}$.
The expected mass of the compound is 302. UV spectrum of compound showed 241 and 271 nm.

From the above details $^1$H, $^{13}$C NMR, IR, UV and GC-MS techniques the possible structure of the compound is predicted as quercetin.

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\begin{align*}
\text{Fig: Quercetin}
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4.6 Effect of quercetin from *A. lebbeck* against *Cx. quinquefasciatus*, *Ae. aegypti* and *An. stephensi*

4.6.1 Larvicidal activity of quercetin

The effect of different concentrations of quercetin on the larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* are presented in Table 4.61.

The results revealed that the highest larval mortality was observed in *An. stephensi* with the LC$_{50}$ values of 2.29 ppm followed by *Ae. aegypti* and *Cx. quinquefasciatus* with the LC$_{50}$ values of 4.49 and 7.03 ppm, respectively. The LC$_{90}$ values of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* were 4.01, 8.06 and 12.27 ppm, respectively. The chi-square values were significant at 0.05 per cent level.
4.6.2 Ovicidal activity of quercetin

The effect of quercetin on the egg of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* were presented in Table 4.62.

In the present study, the different concentrations used were 20.0, 40.0, 60.0, 80.0, 100.0 and 120.0 ppm. The 100% egg mortality of 0-6 h egg rafts of *Cx. quinquefasciatus* were 60 ppm, whereas 100% egg mortality of 6-12 and 12-18 h old eggs were in 80 ppm. In *Ae. aegypti* 0-6 and 6-12 h old eggs were attained zero hatchability (100 percent mortality) was at the concentration of 80 ppm, while the 12-18 h eggs attained the zero hatchability at 100 ppm. The complete ovicidal activity of *An. stephensi* 0-6 h old eggs were attained at the concentration of 40 ppm with 6-12 and 12-18 h eggs were in 60 ppm. Control eggs showed 100 percent hatchability.

4.6.3 Adulticidal activity of quercetin

Effect of different concentrations of quercetin against the adult *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* mosquitoes are presented in Table 4.63.

The results revealed that the highest adult mortality was observed in *An. stephensi* with the LC\textsubscript{50} values of 21.81 ppm followed by *Ae. aegypti* and *Cx. quinquefasciatus* with the LC\textsubscript{50} values of 24.80 and 27.16 ppm, respectively. The LC\textsubscript{90} values of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* were 40.73, 43.59 and 46.32 ppm, respectively. The chi-square values were significant at 0.05 per cent level.

4.6.4 Repellent activity of quercetin

Repellent activity of quercetin against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* are presented in Table 4.64. The quercetin provide significant repellency against *An. stephensi* followed by *Ae. aegypti* and *Cx. quinquefasciatus*. The higher concentration of 5.0mg/cm\textsuperscript{2} provides 100 % protection up to 420, 360 and 300 minutes, respectively. The lower concentration 1.0 mg/cm\textsuperscript{2} provided 100% protection up to 300, 240 and 180 minutes, respectively.