

## Supporting Information

### GC-MS analysis result of EOs

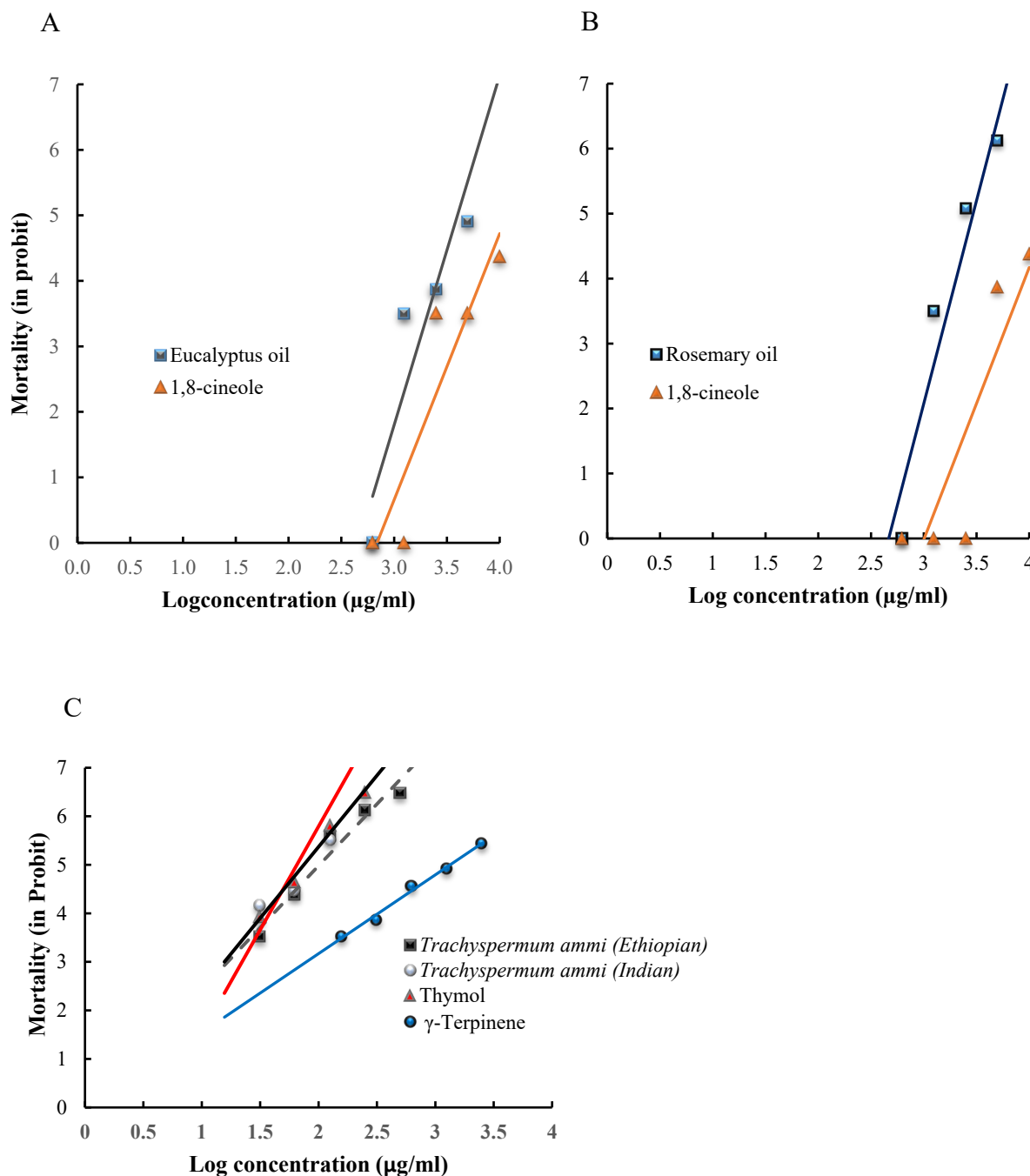
**Table S1.** All Main components (%) detected by GC-MS in essential oils

| No | Compounds <sup>a</sup> | RI <sup>b</sup> | Ri <sup>c</sup> | <i>E.</i><br><i>globulus</i> | R.<br><i>officinalis</i> | <i>T.</i><br><i>schimperi</i> <sup>d</sup> | <i>T.</i><br><i>ammi</i> <sup>e</sup> | <i>T.</i><br><i>ammi</i> <sup>f</sup> |
|----|------------------------|-----------------|-----------------|------------------------------|--------------------------|--|---------------------------------------|---------------------------------------|
| 1  | $\alpha$ -Thujene      | 926.3           | 927.8           | 0.18                         |                          | 0.92                                       | 0.79                                  | 0.051                                 |
| 2  | $\alpha$ -Pinene       | 931.7           | 936.1           | 15.19                        | 3.84                     | 0.25                                       | 0.58                                  | 0.037                                 |
| 3  | Camphene               | 947.8           | 950.3           | 0.41                         | 2.89                     |  |                                       |                                       |
| 4  | $\beta$ -Pinene        | 973.5           | 977.7           | 1.84                         | 2.42                     | 0.07                                       | 4.56                                  | 0.78                                  |
| 5  | 1-Octen-3-ol           | 980.2           | 980.0           |                              |                          | 0.40                                       |                                       |                                       |
| 6  | 3-Octanone             | 986.2           | 984.5           |                              |                          | 1.63                                       |                                       |                                       |
| 7  | $\beta$ -Myrcene       | 991.8           | 989.2           | 2.38                         |                          | 0.92                                       | 1.07                                  | 0.225                                 |
| 8  | 3-Octanol              | 996.4           | 993.2           |                              |                          | 0.82                                       |                                       |                                       |
| 9  | $\alpha$ -Phellandrene | 1002.4          | 1004.1          | 2.81                         |                          | 0.18                                       | 0.94                                  |                                       |
| 10 | 3-Carene               | 1008.6          | 1011.3          |                              |                          |  | 0.12                                  |                                       |
| 11 | $\alpha$ -Terpinene    | 1015.8          | 1017.1          |                              |                          | 1.96                                       | 0.55                                  | 0.249                                 |
| 12 | p-Cymene               | 1027.3          | 1024.3          |                              |                          | 14.20                                      | 27.92                                 | 17.72                                 |
| 13 | Limonene               | 1027.3          | 1029.5          |                              |                          |  |                                       | 0.117                                 |
| 14 | $\alpha$ -Sabinene     | 1029.7          | -               |                              |                          | 0.88                                       |                                       |                                       |
| 15 | 1,8- Cineole           | 1033.1          | 1031.8          | 56.72                        | 29.29                    |  |                                       |                                       |
| 16 | $\gamma$ -Terpinene    | 1061.2          | 1059.7          | 1.88                         |                          | 8.52                                       | 32.72                                 | 17.02                                 |
| 17 | (Z)-Sabinene hydrate   | 1065.7          | 1066.5          |                              |                          | 0.35                                       | 0.14                                  | 0.043                                 |
| 18 | Cis-Linanol oxides     | 1072.1          | 1075.1          | 0.15                         |                          |  |                                       |                                       |
| 19 | $\alpha$ -Terpinolene  | 1087.3          | 1086.9          |                              |                          | 0.29                                       |                                       | 0.172                                 |
| 20 | (E)-Sabinene hydrate   | 1096.0          | 1098.1          |                              |                          |  | 0.17                                  |                                       |
| 21 | Linalool               | 1100.4          | 1099.0          |                              | 2.73                     | 2.68                                       | 1.21                                  | 0.045                                 |
| 22 | Undecane               | 1102.1          | 1100.0          |                              |                          |  | 0.12                                  |                                       |
| 23 | Camphor                | 1140.6          | 1143.4          |                              | 16.08                    |  |                                       |                                       |
| 24 | (Z)-Verbenol           | 1149.5          | 1144.4          |                              |                          |  | 0.13                                  |                                       |
| 25 | Isoborneol             | 1156.9          | 1158.2          |                              | 7.32                     |  |                                       |                                       |
| 26 | P-Mentha-1,5-dien-8-ol | 1166.0          | 1166.6          |                              |                          |  | 1.21                                  |                                       |
| 27 | Terpinen-4-ol          | 1175.8          | 1177.1          | 1.06                         | 2.48                     | 1.16                                       | 0.85                                  | 0.374                                 |
| 28 | $\alpha$ -Terpineol    | 1190.4          | 1187.7          | 7.28                         |                          | 0.74                                       | 0.28                                  | 0.168                                 |

|       |                             |        |        |      |       |       |        |
|-------|-----------------------------|--------|--------|------|-------|-------|--------|
| 29    | Carvestrene                 | 1195.2 |        | 8.58 |       |       |        |
| 30    | (E)-Dihydrocarvone          | 1203.5 | 1201.4 |      | 0.15  |       |        |
| 31    | (Z)-Dihydrocarvone          | 1217.9 | -      |      | 0.10  |       |        |
| 32    | Thymol methyl ether         | 1243.3 | 1234.3 |      | 0.15  |       |        |
| 33    | Geraniol                    | 1252.6 | 1254.9 | 0.64 |       |       |        |
| 34    | (Z)-2,3- Epoxydecane        | 1264.2 | -      |      | 0.15  |       |        |
| 35    | Trans-Anethole              | 1280.7 | 1285.2 | 0.43 |       |       |        |
| 36    | Bornyl acetate              | 1282.4 | 1285.2 | 1.92 |       |       |        |
| 37    | Thymol                      | 1292.5 | 1290.1 | 0.94 | 23.03 | 24.36 | 59.402 |
| 36    | Carvacrol                   | 1301.4 | 1300.4 |      | 34.84 | 0.51  | 0.123  |
| 39    | $\alpha$ -Cubebene          | 1349.5 | 1351.4 | 0.95 |       |       |        |
| 40    | Thymol acetate              | 1355.3 | 1356.4 |      | 0.55  | 0.20  |        |
| 41    | Eugenol                     | 1356.5 | 1357.8 |      |       |       | 0.57   |
| 42    | Carvacryl acetate           | 1373.2 | 1373.1 |      | 0.75  | 0.10  | 0.26   |
| 43    | Geranyl acetate             | 1380.9 | 1379.9 | 0.62 |       |       |        |
| 44    | Cis-Caryophyllene           | 1404.0 | 1406.5 | 6.69 |       |       |        |
| 45    | (E)-Caryophyllene           | 1422.3 | 1420.1 |      | 0.49  |       |        |
| 46    | $\beta$ -Humulene           | 1439.9 | 1442.5 | 1.58 |       |       |        |
| 47    | Aromandendrene              | 1440.4 | 1440.6 | 3.13 | 1.24  |       |        |
| 48    | $\gamma$ -Muurolene         | 1471.4 | 1476.2 | 1.43 |       |       |        |
| 49    | (Z)- $\beta$ -Farnesene     | 1486.7 | -      |      | 0.04  |       |        |
| 50    | $\alpha$ -Muurolene         | 1495.2 | 1498.3 | 0.51 |       |       |        |
| 51    | $\alpha$ -Bisabolene        | 1503.6 | 1508.4 | 0.46 |       |       |        |
| 52    | $\beta$ -Bisabolene         | 1510.9 | 1508.4 |      | 0.04  |       |        |
| 53    | $\beta$ -Sesquiphellandrene | 1524.7 | 1523.5 |      | 0.18  |       |        |
| 54    | Caryophyllene oxide         | 1582.7 | 1580.6 | 2.63 | 0.38  |       |        |
| 55    | $\gamma$ -Eudesmol          | 1632.1 | 1630.9 | 0.34 |       |       |        |
| 56    | Epi- $\alpha$ -Cadinol      | 1639.5 | 1637.8 | 0.26 |       |       |        |
| 57    | $\alpha$ -Muurolol          | 1645.6 | 1642.9 | 1.28 |       |       |        |
| Total |                             |        | 96.2   | 95.4 | 96.7  | 98.7  | 96.8   |

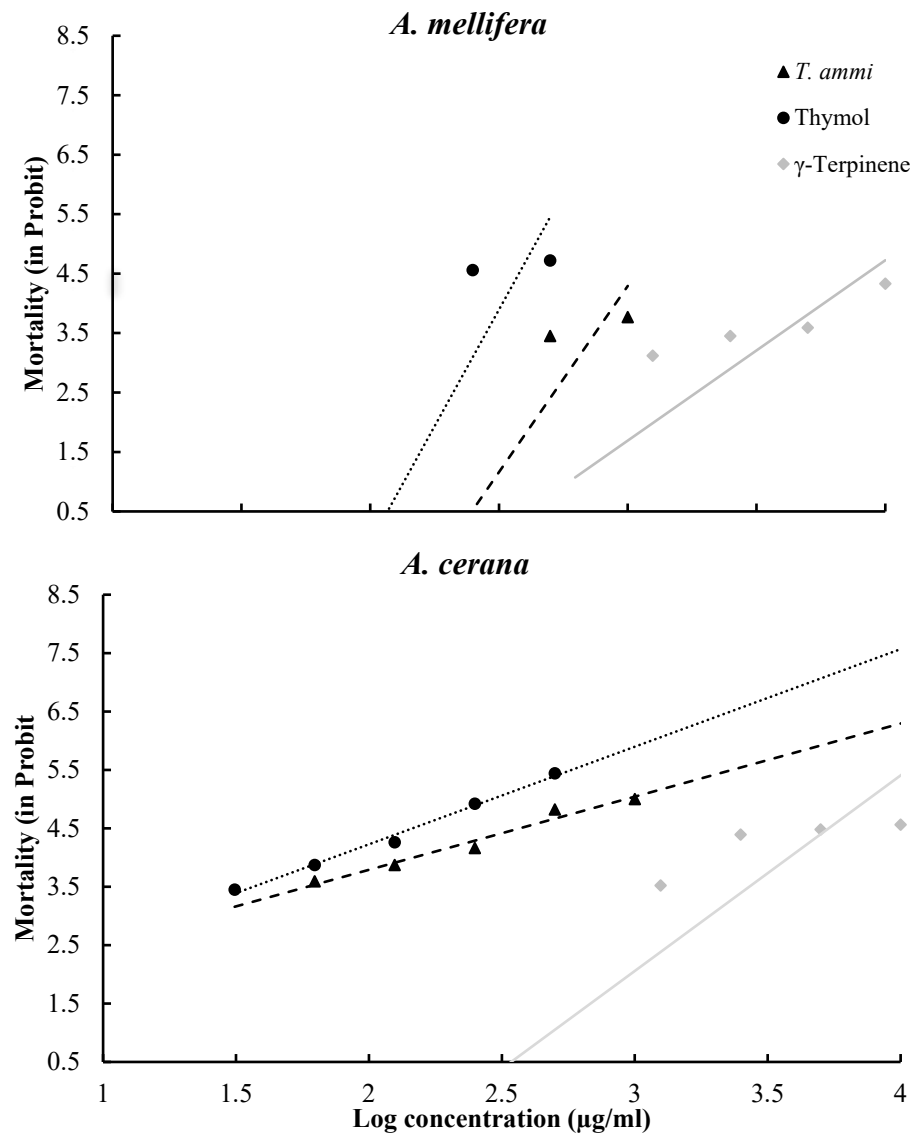
Note: <sup>a</sup> Compounds listed in order of elution; <sup>b</sup> RI and <sup>c</sup> RI are the Kovats retention indices determined relative to a series of *n*-alkanes (C9–C29) on a non-polar (HP5-MS type column) capillary column, respectively, under conditions listed in the Materials and Methods section; constituents of the essential oils were identified by comparing their Kovats retention indices(RIs) with those reported in the literature (Babushok, 2011) and their mass spectra with those listed in Wiley mass spectral library. <sup>d</sup>Bisrat et al., [28], <sup>e</sup>Ethiopian variety, <sup>f</sup>Indian variety

## Dose Response Curve of the EOs and Their Major Components on *Varroa destructor*



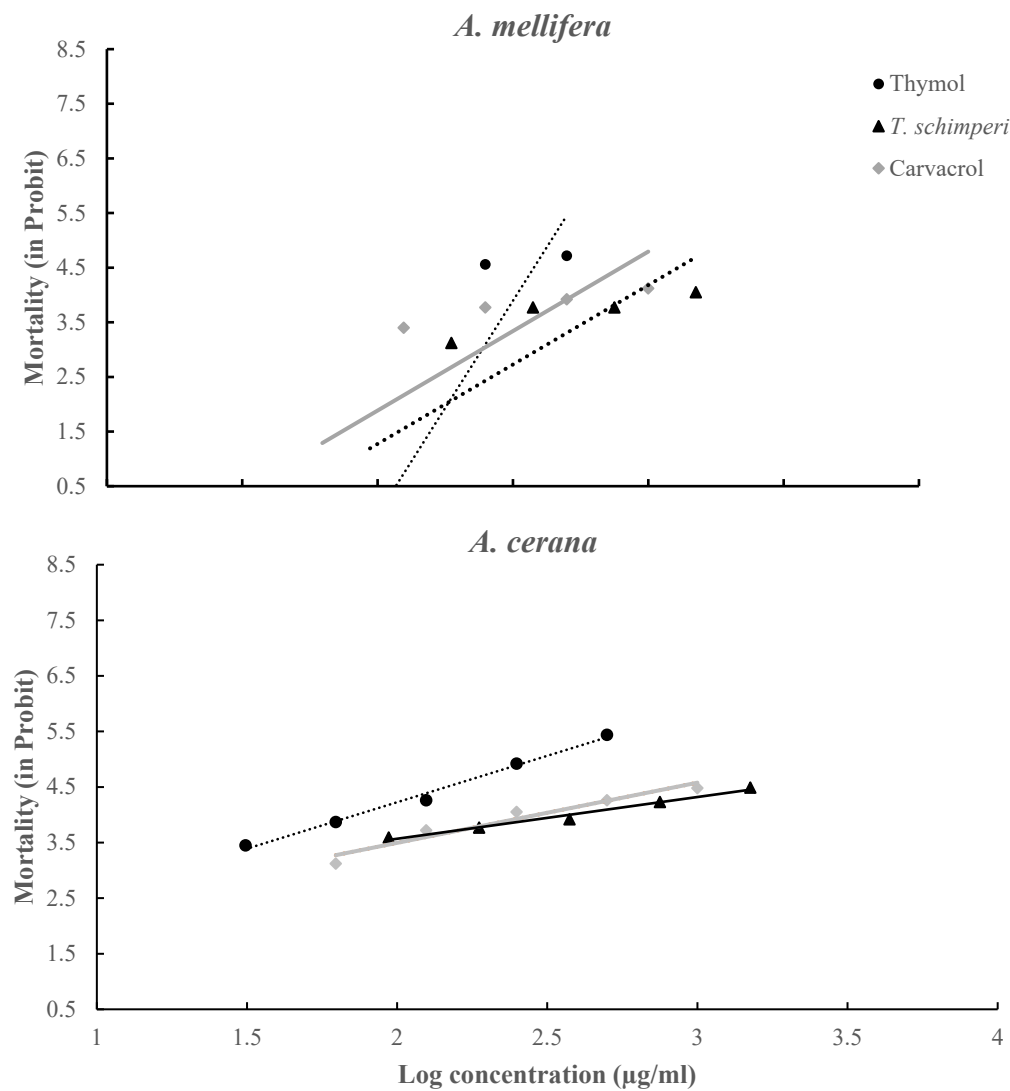
**Figure S1.** Dose-response lines of essential oils than *E. globulus* (A), *R. officinalis* (B) and *T. ammi* (C) and their components 1, 8- cineole, thymol and  $\gamma$ -terpinene 4-h after of exposure.

# Surface Treatment Dose Response Curve of *T. ammi* and Its Major Components on Honey bees



**Figure S2.** Dose-response lines of *T. ammi* and its main components (thymol, and  $\gamma$ -terpinene) to *A. mellifera* and *A. cerana* 4-h after treatment exposure.

# Surface treatment Dose response curve of *T. schimepri* and Its Major Components on Honey bees



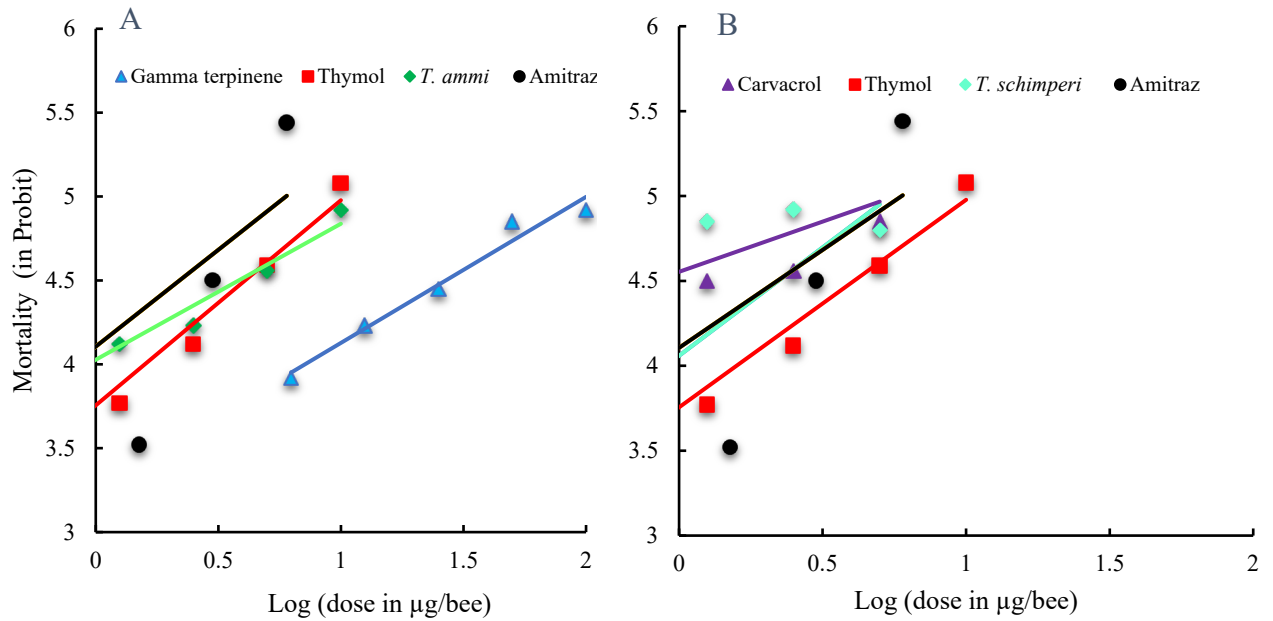
**Figure S3.** Dose-response lines of *T. schimepri* and its main components (thymol, and carvacrol) to *A. mellifera* and *A. cerana* 4-h after treatment exposure

### Estimated LC<sub>50</sub> of *T. schimperi*, *T. ammi* and Their Major Components on Honey bees

**Table S2.** Estimated 4-h post exposure lethal concentration (LC<sub>50</sub>), 95% confidence limits (CL) *T. schimperi* and *T. ammi* EOs, their major components (thymol, carvacrol and  $\gamma$ -terpinene) and tau-fluvalinate against honey bees.

| Test samples        | Species             | Probit Analysis |                  |             |                |           |          |    |
|---------------------|---------------------|-----------------|------------------|-------------|----------------|-----------|----------|----|
|                     |                     | N               | LC <sub>50</sub> | 95% CL      | Slope $\pm$ SE | Intercept | $\chi^2$ | df |
| <i>T. schimperi</i> | <i>A. mellifera</i> | 180             | 9971             | 2868-16,300 | 1.1 $\pm$ 0.4  | 0.7       | 6.9      | 13 |
|                     | <i>A. cerana</i>    | 150             | 2946             | 1017- 4131  | 0.8 $\pm$ 0.2  | -2.2      | 2.9      | 13 |
| <i>T. ammi</i>      | <i>A. mellifera</i> | 180             | 4700             | 1553 -5911  | 1.9 $\pm$ 0.9  | -2.0      | 10.3     | 13 |
|                     | <i>A. cerana</i>    | 150             | 943              | 572.9-2267  | 1.2 $\pm$ 0.3  | 2.7       | 14.6     | 13 |
| Thymol              | <i>A. mellifera</i> | 180             | 460.9            | 259 –1698   | 2.9 $\pm$ 0.6  | -2.6      | 71.4     | 13 |
|                     | <i>A. cerana</i>    | 150             | 315              | 229 – 506   | 1.8 $\pm$ 0.3  | 0.8       | 12.9     | 13 |
| Carvacrol           | <i>A. mellifera</i> | 180             | 4107             | 1592-       | 3.7 $\pm$ 0.4  | 0.4       | 3.8      | 13 |
|                     | <i>A. cerana</i>    | 150             | 2994             | 1135-       | 4.0 $\pm$ 0.3  | 1.6       | 3.6      | 13 |
| $\gamma$ -Terpinene | <i>A. mellifera</i> | 180             | 51129            | 13655-78463 | 1.2 $\pm$ 0.4  | 0.8       | 22.7     | 13 |
|                     | <i>A. cerana</i>    | 150             | 15826            | 6033-22180  | 1.2 $\pm$ 0.3  | 0.2       | 35.4     | 13 |
| Fluvalinate         | <i>A. mellifera</i> | 180             | 135              | 63-355      | 0.8 $\pm$ 0.1  | 3.3       | 4.5      | 13 |
|                     | <i>A. cerana</i>    | 150             | 120              | 99-266      | 0.8 $\pm$ 0.1  | 3.4       | 4.8      | 13 |

# Topical Exposure Dose Response Curve of *T. schimperi* and *T. ammi* and Their Major Components on *A. mellifera*



**Figure S4.** Dose-response lines of the mortality of *T. ammi* (A) and *T. schimperi* (B) and their major components (carvacrol, thymol,  $\gamma$ -terpinene) to *A. mellifera* 4-h post topical exposure