# An evaluation of insecticidal activities and phytochemical properties of selected members of the family Meliaceae used traditionally as insecticides in southern Africa.

**Calphonia Shilaluke and Prof. Annah Moteetee**

Department of Botany and Plant Biotechnology, University of Johannesburg, P.O. Box 524, Auckland Park, 2006, South Africa

## INTRODUCTION

Storage and field insect pests destroy about one-third of the global food production every year. Synthetic pesticides are the commonly used and highly effective means of controlling insect pests. However, their indiscriminate use results in environmental and health hazards to both humans and animals. Plants are known to be rich sources of bioactive chemicals, and more than 2 000 plant species are known to possess insecticidal properties. Hence, plant-derived botanicals have emerged as a promising alternative to chemical pesticides due to their non-persistence, high selectivity, and low mammalian toxicity.


## AIMS AND OBJECTIVES

The aim of the study was to assess the antifeedant and insecticidal properties of selected South African species of the family Meliaceae against *Plutella xylostella* (diamondback moth, DBM) and *Spodoptera frugiperda* (fall armyworm, FAW) and evaluate their phytochemical properties.

## MATERIALS & METHODS

### Insecticidal and antifeedant activities.

1. Feeding deterrence test (using maize leaves as test food for FAW and cabbage for DBM).
   - Leaves were saturated by dipping in 1.0% extracts solutions of either water, acetone or ethanol and weighed before presenting them to five FAW and DBM

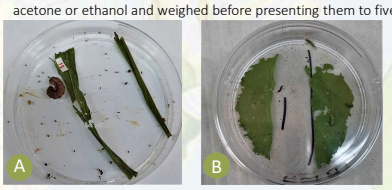


Figure 1: Feeding deterrence bioassay of fall armyworm **(A)** and the feeding deterrence bioassay of diamondback moth **(B)**.

2. Topical application bioassay.
   - Ten microliters of each 0.5 or 1.0% aqueous, acetone or ethanol extract solution were applied to the dorsum of each larva.
   - Five larvae were treated at each dose and then transferred to a petri dish.

### Qualitative phytochemical analysis.

1. Preliminary phytochemical screening.


2. GC-HRT- MS analyses.
   - The samples were analyzed on the GC-HRT- MS system which was equipped with an Agilent 7890A gas chromatograph (Agilent Technologies, Inc., Wilmington, DE, USA).
   - For each plant extract, a volume of 1 µl was injected in a spitless mode.

## RESULTS & DISCUSSIONS

### Insecticidal activities.

### 1. Feeding deterrence bioassay.

Table 1: Feeding deterrence test results for the **fall armyworm** larvae. Efficacy of extracts were ranked using the following rankings: total coefficient deterrence value of between 150 – 200 = ++++, 100 – 150 = +++, 50 – 100 = ++ and 0 – 50 = +.

| Plant species | Extract | Coefficient of deterrence | | | Efficacy of extracts | F value (P value) |
|---|---|---|---|---|---|---|
| | | Absolute (A) | Relative (R) | Total (T) | | |
| *1. Cedrela odorata* | Aqueous | 4.38 | -34.26 | -29.88 | 0 | 0,16 (0.86) |
| | Acetone | 45.25 | 70.60 | 115.85 | +++ | |
| | Ethanol | 20.11 | 18.89 | 39 | + | |
| *2. Ekebergia capensis* | Aqueous | 21.66 | 26.61 | 48.27 | + | 2.04 (0.21) |
| | Acetone | 25.14 | 19.97 | 45.11 | + | |
| | Ethanol | -10.77 | 28.55 | 17.78 | + | |
| *3. Khaya anthotheca* | Aqueous | 35.39 | 12.30 | 47.69 | + | 0.54 (0.61) |
| | Acetone | 11.33 | 11.72 | 23.05 | + | |
| | Ethanol | -2.55 | 4.04 | 1.49 | + | |
| *4. Melia azedarach* | Aqueous | 48.04 | 35.88 | 83.92 | ++ | 4.40 (0.06) |
| | Acetone | 58.14 | 3.43 | 61.57 | ++ | |
| | Ethanol | 28.96 | 8.39 | 37.35 | + | |
| *5. Toona ciliata* | Aqueous | 22.53 | 12.41 | 34.94 | + | 5.72 (0.04) |
| | Acetone | 6.22 | 30.99 | 37.21 | + | |
| | Ethanol | 23.38 | 21.23 | 44.61 | + | |
| *6. Trichilia emetica* | Aqueous | 43.56 | 24.78 | 68.34 | ++ | 5.92 (0.04) |
| | Acetone | 32.39 | 35.76 | 68.15 | ++ | |
| | Ethanol | 28.62 | 11.15 | 39.77 | + | |
| *7. Trichilia dregeana* | Aqueous | 29.95 | 32.07 | 62.02 | ++ | 13.71 (0.005) |
| | Acetone | 29.01 | 23.84 | 52.85 | ++ | |
| | Ethanol | 14.30 | 31.99 | 46.29 | + | |
| *8. Turraea floribunda* | Aqueous | 24.40 | 42.56 | 66.96 | ++ | 0.20 (0.82) |
| | Acetone | 17.86 | 3.04 | 20.90 | + | |
| | Ethanol | 3.04 | -15.93 | -12.89 | 0 | |
| *9. Turraea obtusifolia* | Aqueous | 40.91 | 26.38 | 67.29 | ++ | 3.69 (0.09) |
| | Acetone | 17.51 | 17.17 | 34.65 | + | |
| | Ethanol | 27.06 | 41.38 | 68.44 | ++ | |

- Highest feeding deterrence against the fall armyworm larvae was recorded from the acetone extracts of *Cedrela odorata*.
- Aqueous extracts of Cedrela odorata and ethanolic extracts of *Turraea floribunda* were found to have inert compounds against the larvae.

Table 2: Feeding deterrence test results for the **diamondback moth** larvae.

| Plant species | Extract | Coefficient of deterrence | | | Efficacy of extract | F value (P value) |
|---|---|---|---|---|---|---|
| | | Absolute (A) | Relative (R) | Total (T) | | |
| *1. Cedrela odorata* | Aqueous | 78.34 | 18.21 | 96.55 | ++ | 4.54 (0.06) |
| | Acetone | 66.55 | 42.05 | 108.6 | +++ | |
| | Ethanol | 27.49 | 84.06 | 111.55 | +++ | |
| *2. Ekebergia capensis* | Aqueous | 27.65 | 3.61 | 31.26 | + | 2.39 (0.17) |
| | Acetone | 50.60 | 2.57 | 53.17 | ++ | |
| | Ethanol | 40.39 | 45.40 | 85.79 | ++ | |
| *3. Khaya anthotheca* | Aqueous | 32.62 | 13.57 | 46.19 | + | 9.29 (0.01) |
| | Acetone | 53.20 | 23.91 | 77.11 | ++ | |
| | Ethanol | 49.11 | 1.81 | 50.92 | ++ | |
| *4. Melia azedarach* | Aqueous | 34.79 | 3.34 | 38.13 | + | 13.56 (0.006) |
| | Acetone | 32.89 | 13.55 | 46.44 | + | |
| | Ethanol | 56.13 | 4.13 | 60.26 | ++ | |
| *5. Toona ciliata* | Aqueous | 56.26 | 20.89 | 77.15 | ++ | 3.37 (0.10) |
| | Acetone | 60.59 | -67.50 | -6.91 | 0 | |
| | Ethanol | 38.81 | -51.48 | -12.67 | 0 | |
| *6. Trichilia emetica* | Aqueous | 50.31 | 35.61 | 85.92 | ++ | 343.09 (6.51) |
| | Acetone | 49.72 | 39.29 | 89.01 | ++ | |
| | Ethanol | 47.75 | 42.32 | 90.07 | ++ | |
| *7. Trichilia dregeana* | Aqueous | 45.85 | 52.92 | 98.77 | ++ | 34.83 (0.0005) |
| | Acetone | 62.37 | 49.88 | 112.25 | +++ | |
| | Ethanol | 63.52 | 35.87 | 99.39 | ++ | |
| *8. Turraea floribunda* | Aqueous | 34.70 | -20.75 | 13.95 | + | 22.48 (0.002) |
| | Acetone | 49.41 | -23.48 | 25.93 | + | |
| | Ethanol | 49.65 | -5.43 | 44.22 | + | |
| *9. Turraea obtusifolia* | Aqueous | 42.24 | 44.50 | 86.74 | ++ | 3.69 (0.09) |
| | Acetone | 38.94 | 0.94 | 39.88 | + | |
| | Ethanol | 55.43 | -1.06 | 54.37 | ++ | |

- Most plant extracts indicated exceptionally high feeding deterrence against the diamondback moth as compared to the fall armyworm larvae.
- Aqueous and ethanol extracts of *Cedrela odorata* and acetone extracts of *Trichilia dregeana* recorded the most feeding deterrence.
- Acetone and ethanol extracts of *Toona ciliata* were found to have inert compounds against the larvae.

### 2. Topical application bioassay.

Table 3: Topical application bioassay results for the **fall armyworm** larvae.

| Plant species | Extracts | Average of % dead | $LD_{50}$ (mg/kg) |
|---|---|---|---|
| *1. Cedrela odorata* | Aqueous | 50 | 707.95 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 50 | 707.95 |
| *2. Ekebergia capensis* | Aqueous | 80 | 0.14 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 40 | 851.14 |
| *3. Khaya anthotheca* | Aqueous | 20 | 6.92 |
| | Acetone | 20 | 6.92 |
| | Ethanol | 80 | 0.14 |
| *4. Melia azedarach* | Aqueous | 50 | 707.95 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 50 | 707.95 |
| *5. Toona ciliata* | Aqueous | 50 | 707.95 |
| | Acetone | 70 | 371.54 |
| | Ethanol | 70 | 371.54 |
| *6. Trichilia emetica* | Aqueous | 30 | 1348.96 |
| | Acetone | 70 | 371.54 |
| | Ethanol | 70 | 371.54 |
| *7. Trichilia dregeana* | Aqueous | 50 | 707.95 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 60 | 588.84 |
| *8. Turraea floribunda* | Aqueous | 60 | 0.56 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 20 | 6.92 |
| *9. Turraea obtusifolia* | Aqueous | 70 | 371.54 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 70 | 371.54 |

- Probability unit (Probit) analysis indicate that the extracts with the lowest $LD_{50}$ values are more toxic to the larvae, and the ones with the highest values are less toxic.
- Aqueous extracts of *Ekebergia capensis* and ethanol extracts of *Khaya anthotheca* are more toxic to the fall armyworm larvae.
- Aqueous extracts of *Trichilia emetica* is less toxic to the larvae.

Table 4: Topical application bioassay results for the **diamondback moth** larvae.

| Plant species | Extracts | Average of % dead | $LD_{50}$ (mg/kg) |
|---|---|---|---|
| *1. Cedrela odorata* | Aqueous | 60 | 0.56 |
| | Acetone | 70 | 1318.26 |
| | Ethanol | 30 | 371.54 |
| *2. Ekebergia capensis* | Aqueous | 50 | 691.83 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 50 | 691.83 |
| *3. Khaya anthotheca* | Aqueous | 60 | 588.84 |
| | Acetone | 30 | 1318.26 |
| | Ethanol | 50 | 691.83 |
| *4. Melia azedarach* | Aqueous | 80 | 0.14 |
| | Acetone | 80 | 0.14 |
| | Ethanol | 80 | 0.14 |
| *5. Toona ciliata* | Aqueous | 30 | 1318.26 |
| | Acetone | 30 | 371.54 |
| | Ethanol | 40 | 1.78 |
| *6. Trichilia emetica* | Aqueous | 60 | 371.54 |
| | Acetone | 60 | 1318.26 |
| | Ethanol | 50 | 707.95 |
| *7. Trichilia dregeana* | Aqueous | 50 | 691.83 |
| | Acetone | 50 | 707.95 |
| | Ethanol | 50 | 691.83 |
| *8. Turraea floribunda* | Aqueous | 60 | 851.14 |
| | Acetone | 40 | 851.14 |
| | Ethanol | 50 | 707.95 |
| *9. Turraea obtusifolia* | Aqueous | 40 | 1.78 |
| | Acetone | 30 | 1318.26 |
| | Ethanol | 70 | 1318.26 |

- All three different extracts of Melia azedarach were found to be more toxic to the diamondback moth larvae.
- Quite a number of different plant extracts displayed insignificant toxicity to the diamondback moth larvae as compared to the fall armyworm larvae.

### Qualitative phytochemical screening

### 1. Preliminary phytochemical screenings results.

Table 5: Preliminary phytochemical screening results evaluating the presence or absence of alkaloids, coumarins, flavonoids, phenols and tannins, saponins and terpenoids in plant extracts. + = presence, - = absence

| Plant species | Secondary metabolites | | | | | |
|---|---|---|---|---|---|---|
| | Alkaloids | Flavonoids | Terpenoids | Phenols and tannins | Saponins | Coumarins |
| *1. Cedrela odorata* | + | + | + | + | + | + |
| *2. Ekebergia capensis* | + | + | + | + | + | - |
| *3. Khaya anthotheca* | + | + | + | + | + | + |
| *4. Melia azedarach* | + | + | + | + | + | + |
| *5. Toona ciliata* | - | + | - | + | + | - |
| *6. Trichilia emetica* | + | - | + | + | + | - |
| *7. Trichilia dregeana* | + | + | + | + | + | - |
| *8. Turraea floribunda* | + | + | + | + | + | + |
| *9. Turraea obtusifolia* | + | + | + | + | + | - |

- Secondary metabolites of importance are terpenoids, alkaloids and phenolic compounds.
- All the plant extracts contain at least one of these importance secondary metabolites , which credit their insecticidal and antifeedant properties observed.

### 2. GC-HRT- MS analyses.

Table 6: active compounds which are present in each plant species

| Plant species | Number of active chemical compound |
|---|---|
| *1. Cedrela odorata* | 57 |
| *2. Ekebergia capensis* | 74 |
| *3. Khaya anthotheca* | 36 |
| *4. Melia azedarach* | 53 |
| *5. Toona ciliate* | 61 |
| *6. Trichila emetica* | 77 |
| *7. Trichilia dregeana* | 72 |
| *8. Turraea floribunda* | 85 |
| *9. Turraea obtusifolia* | 89 |

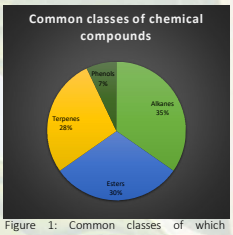


Figure 1: Common classes of which chemical compounds were classified.

- Active chemical compounds identified in each plant extracts (table 6) were classified into secondary metabolites classes (figure 1).
- Phenols and terpenes are the note worthy and well-known groups; they are known to have insecticidal and antifeedant properties.

## CONCLUSION

- The data obtained in this study confirmed many previous reports and can lead to the conclusion that Meliaceae extracts can be considered as effective botanical insecticides
- Phytochemical contents of plant extracts evaluated correlate with their insecticidal and antifeedant activities against the fall armyworm and the diamondback moth
- Out of the nine selected species evaluated, five of them merit further investigation as they have shown excellent results;
- These are *Cedrela odorata, Ekebergia capensis, Melia azedarach, Trichilia emetica* and *Turraea dregeana.*

## FUTURE RESEARCH

- Further investigation of the potential plant extracts to check if they are able to maintain yield at comparable levels to synthetic pesticides efficacy.
- The trade-off between lower mortality for lower environmental persistence need to be seriously considered, particularly as there is growing evidence that less toxic botanical insecticides can help facilitate natural pest regulation whilst not significantly sacrificing crop yield.

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