Chemical Compositions, Mosquito Larvicidal and Antimicrobial Activities of Leaf Essential Oils of Eleven Species of Lauraceae from Vietnam

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Abstract: The Lauraceae is a family rich in aromatic and medicinal plants. Likewise, essential oils derived from members of this family have demonstrated a myriad of biological activities. It is hypothesized that members of the Lauraceae from Vietnam will yield essential oils that may be useful in controlling mosquito populations and treating microbial infections. In this work, the leaf essential oils of eleven species of Lauraceae (Beilschmiedia erythrophloia, B. robusta, B. yunnanensis, Cryptocarya concinna, C. impressa, C. infectoria, Litsea viridis, Machilus balansa, M. grandifolia, Neolitsea ellipsoidea, and Phoebe angustifolia) have been obtained by hydrodistillation and the chemical compositions analyzed by gas chromatography – mass spectrometry (GC-MS) and gas chromatography with flame ionization detection (GC-FID). The essential oils were screened for larvicidal activity against Aedes aegypti, Ae. albopictus, and Culex quinquefasciatus, and for antimicrobial activity against Enterococcus faecalis, Staphylococcus aureus, Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, Salmonella enterica, and Candida albicans. The leaf essential oil of N. ellipsoidea, rich in (E)-β-ocimene (87.6%), showed excellent larvicidal activity against Ae. aegypti with a 24 h LC₅₀ of 6.59 µg/mL. The leaf essential oil of C. infectoria, dominated by germacrene D (55.5%) and bicyclogermacrene (11.4%), exhibited remarkable larvicidal activity against Cx. quinquefasciatus (48 h LC₅₀ = 0.40 µg/mL). N. ellipsoidea leaf essential oil also demonstrated notable antibacterial activity against E. faecalis and B. cereus with minimum inhibitory concentration (MIC) values of 16 µg/mL, while the leaf essential oil of C. impressa showed excellent antifungal with an MIC of 16 µg/mL.

Leaf essential oils from the Lauraceae should be considered for utilization as alternative agents for controlling mosquito populations and as antimicrobial agents.

Keywords: Beilschmiedia; Cryptocarya; Litsea; Machilus; Neolitsea; Phoebe; Aedes; Culex; antibacterial; antifungal
1. Introduction

The Lauraceae is made up of around 55 genera and 3000 species of tropical and warm temperate trees and shrubs, with Southeast Asia and Brazil serving as species-rich hot spots [1]. Several members of the family are commercially important, including the avocado (Persea americana Mill.) for its fruit, bay leaf (Laurus nobilis L.) used in cooking, and the spice cinnamon (Cinnamomum verum J. Presl) [2]. Several Lauraceae species have been used medicinally, including sassafras (Sassafras albidum (Nutt.) Nees) [3] and spicebush (Lindera benzoin (L.) Blume) [4]. Many species of Lauraceae contain essential oils that have found use in the flavor and fragrance industry [5], e.g., Brazilian rosewood (Aniba rosaeodora Ducke) [6], camphor tree, ravintsara, ho leaf (Cinnamomum camphora (L.) J. Presl) [7], and aromatic litsea (Litsea cubeba (Lour.) Pers.) [8].

Based on the utility and properties of Lauraceae essential oils, it is hypothesized that members of the Lauraceae found in Vietnam have biologically active essential oils that may be useful in controlling mosquito populations or as antimicrobial agents. Eleven species of Lauraceae from north-central Vietnam have been collected, the essential oils obtained by hydrodistillation, chemical compositions analyzed, and the oils screened for mosquito larvicidal activity and for antimicrobial activity.

The genus Beilschmiedia Nees is comprised of around 250 species of trees and shrubs [9] and are widespread in tropical Africa, Madagascar, Asia, Southeast Asia, Melanesia, Australia, New Zealand, North America, Central America, South America, and the Caribbean [10]. The phytochemistry and bioactivity of Beilschmiedia has been reviewed [11].

Beilschmiedia erythrophloia Hayata is a tree found in Taiwan, southern China, Hainan Island, and Ryukyu Islands (Japan) [12,13]. In Vietnam, the tree is found in Nghệ An, Hà Tĩnh, and Đồng Nai provinces [14]. Previous phytochemical studies of Beilschmiedia erythrophloia have revealed endiandric acid derivatives from the roots [15,16], the cytotoxic alkaloid beischamide from the stems [13], and a leaf essential oil rich in (E)-caryophyllene and α-humulene [17].

Beilschmiedia robusta C.K. Allen is a tree, 10–15 m tall that is recorded from Guangzi, southwestern Guizhou, Xizang, and Yunnan provinces in China [12,18]. In Vietnam, the tree is found in Lào Cai, Ninh Bình, and Nghệ An provinces [14]. A perusal of the literature has revealed that there have been no previous phytochemical investigations of Beilschmiedia robusta.

Beilschmiedia yunnanensis H.H. Hu is a tree, up to 18 m tall and is found in Guangdong, southern Guizhou, and southern Yunnan provinces in China [12]. In Vietnam, the tree is found in Lào Cai, Nghệ An, and Hà Tĩnh provinces [14]. A literature search has revealed that there have been no previous phytochemical investigations of Beilschmiedia yunnanensis.

Cryptocarya R. Br. is a pantropical genus of around 300 species [19]. Cryptocarya concinna Hance (syn. Cryptocarya konishii Hayata, Cryptocarya lenticellata Lecomte, Cryptocarya microcarpa F.N. Wei) is a tree up to 18 m tall, and ranges from southern China (Guangdong, Guangxi, southeastern Guizhou, Hainan, Jiangxi, and Taiwan) to northern Vietnam [9,12]. In Vietnam, it has been recorded in Hà Giang, Tuyên Quang, Cao Bằng, Vĩnh Phúc, Hà Nội, Thanh Hóa, Nghệ An, Hà Tĩnh, Thừa Thiên Huế provinces [14]. Previous investigations of the phytochemistry of Cryptocarya concinna have shown the roots to contain cytotoxic cryptocaryone [20], the leaves to contain cytotoxic cryptoconatones K and L [21], and the wood to contain cytotoxic cryptocaryone and kurzichalcolactone A and antifungal cryptocaryone A and kurzichalcolactone B [22]. There have been no previous reports on essential oils from Cryptocarya concinna.

Cryptocarya impressa Miq. is native to Vietnam, Laos, the Malay Peninsula, Borneo and Sumatra [23]. In Vietnam, the plant has been recorded in Hòa Bình, Hà Nội, Hải Dương, Ninh Bình, Nghệ An, and Gia Lai provinces [14]. To our knowledge, there have been no reports on the phytochemistry of Cryptocarya impressa.

Cryptocarya infectoria (Blume) Miq. (syn. Cylicodaphne infectoria Blume) is a tree up to 33 m tall that is native to Indo-China and Malesia [24–26]. In Vietnam, this tree is found in Lào Cai, Phú Thọ, Vĩnh Phúc, Thanh Hóa, Nghệ An, Hà Tĩnh, and Thừa Thiên Huế provinces [14]. The cytotoxic dihydrochalcones, cryptocaryone and infectocaryone, and the flavonoids cryptocaryanones A and B...
have been isolated from the methanol bark extract of *C. infectoria* [27,28]. The isoquinoline alkaloids atherosperminine, N-methylisococaurine, and N-methylauracetanine have also been isolated from the bark of *C. infectoria* [29]. There have been apparently no essential oil analyses on this plant, however.

The genus *Litsea* Lam. consists of around 300 species distributed in tropical and warm subtropical regions of Asia, Australia, and the Americas [19]. *Litsea viridis* H. Liu is a small tree, 3-6 m tall, found in south-eastern Yunnan province (China) and Cao Bằng, Nghệ An, Đà Nẵng, and Đắk Lắk provinces (Vietnam) [12,14]. There do not seem to be any previous studies on the phytochemistry of this plant.

The genus *Machilus* Rumph. ex Nees is comprised of around 100 species distributed in southern and south-eastern Asia [12,14]. *Machilus balansae* (Airy Shaw) F.N. Wei & S.C. Tang (syn. *Persea balansae* Airy Shaw) is endemic to Vietnam and is generally found at low elevations in north Vietnam [30]. *Machilus grandifolia* S.K. Lee & F.N. Wei is now regarded as a new synonym of *M. balansae* [30]. To our knowledge, there have been no phytochemical studies reported on *M. balansae* or *M. grandifolia*.

The genus *Neolitsea* (Benth.) Merr. Contains around 85 species distributed from Indo-Malaysia to East Asia [12,14]. *Neolitsea ellipsoidea* K.C. Allen is a tree up to 30 m in height [31]. The species has been recorded in Hainan (China) and Vietnam (Hoà Bình, Quảng Ninh, Hà Tĩnh, and Gia Lai provinces). To our knowledge there have been no reports on the phytochemistry of this species.

There are around 100 species in the genus *Phoebe* Nees [19], which range from the Neotropics (Mexico, south to Brazil, Bolivia, and Argentina) and Southeast Asia (southern China, Vietnam, Thailand, Myanmar, Cambodia, and Singapore), as well as Indonesia, New Guinea, and India [9].

*Phoebe angustifolia* Meisn. is a small shrub found in southeastern Yunnan (China), Myanmar, India, and Vietnam [12]. In Vietnam, the species has been recorded in Thanh Hóa, Nghệ An, Thừa Thiên Huế, and Quảng Nam provinces [14]. The leaf essential oil of *P. angustifolia* from Vietnam has been reported, which showed the major components to be spathulenol (17.0%), palmitic acid (13.0%), sabinene (6.4%), and artemisia triene (5.1%) [32].

### 2. Results and Discussion

The essential oil collection details and yields are summarized in Table 1.

**Table 1.** Plant collection and hydrodistillation details of Lauraceae from Vietnam.

| Plant Species                        | Vietnamese Name                     | Collection Site                                | Voucher Number | Collection Month/Year | Yield (% v/w) |
|--------------------------------------|-------------------------------------|------------------------------------------------|----------------|------------------------|---------------|
| *Beilschmiedia erythrophloia* Hayata | Cháp, Két gó đồ                    | Pù Hoàt Nature Reserve; 19°41′40″ N, 104°49′31″ E, elev. 678 m | 803            | 7/2019                | 0.12          |
| *Beilschmiedia robusta* C.K. Allen  | Cháp to khó, Két to khóe            | Pù Hoàt Nature Reserve; 19°41′37″ N, 104°49′30″ E, elev. 677 m | 827            | 9/2019                | 0.14          |
| *Beilschmiedia yunnanensis* H.H. Hu | Cháp vân nam, Két vân nam, Mong vân nam | Vù Quang National park; 18°17′15″ N, 105°21′39″ E, elev. 153 m | 799            | 7/2019                | 0.15          |
| *Cryptocarya concinna* Hance         | Ánh hạch quả vang, Mỏ quả vang, Khiao | Nam Đong District, Thừa Thiên Huế Province; 16°13′9″ N, 107°43′28″ E, elev. 124 m | 791            | 7/2019                | 0.33          |
| *Cryptocarya impressa* Miq. Syn.: *Cryptocarya venosa* Meisn. ex Hook.f. | Mỏ quá to, Mỏ quá xanh, Ánh hạch quá to | Pù Hoàt Nature Reserve; 19°42′18″ N, 104°49′42″ E, elev. 648 m | 801            | 7/2019                | 0.36          |
| *Cryptocarya infectoria* (Blume) Miq. Syn.: *Cargadophane infectoria* Blume | Cả đuôi nhùm, Ánh hạch nhùm, Cả đuôi tai nhéºº | Pù Hoàt Nature Reserve; 19°42′18″ N, 104°49′42″ E, elev. 648 m | 767            | 4/2019                | 0.25          |
| *Litsea viridis* H. Liou             | Bơi lơi xanh                       | Pù Hoàt Nature Reserve; 19°42′18″ N, 104°49′42″ E, elev. 648 m | 806            | 8/2019                | 0.21          |
Table 1. Cont.

| Plant Species                  | Vietnamese Name               | Collection Site                                                                 | Voucher Number | Collection Month/Year | Yield (% v/w) |
|--------------------------------|--------------------------------|--------------------------------------------------------------------------------|----------------|-----------------------|---------------|
| Machilus balansa (Airy Shaw)   | Syn.: Persea balansae         | Klao balansa, Re balansa                                                       | 828            | 9/2019                | 0.42          |
| Machilus grandifolia S.K. Lee & | F.N. Wei                       | Nam Dông District, Thu Thien Huệ Province; 16°13’9’’ N, 107°43’28’’ E, elev. 124 m | 779            | 7/2019                | 0.18          |
| Neolitsea ellipsoidea K.C. Allen| Syn.: Phoebe angustifolia var. anamensis Liou | Nô bầu duc, Bái hương là bão duc, Tam càng | 802            | 7/2019                | 0.31          |
| Phoebe angustifolia Meisn.     | Syn.: Phoebe angustifolia var. anamensis Liou | Re tràng là hep, Su là hep, Đa đa mò cát | 785            | 7/2019                | 0.45          |

2.1. Essential Oil Compositions

The essential oil compositions of B. erythrophloia, B. robusta, and B. yunnanensis are compiled in Table 2. All three of the Beilschmiedia leaf essential oils were dominated by sesquiterpene hydrocarbons. A preponderance of sesquiterpene hydrocarbons has been previously seen in Beilschmiedia leaf essential oils from Malaysia [33] and from Costa Rica [34].

Table 2. Chemical compositions of the leaf essential oils of Beilschmiedia species collected in Vietnam.

| RI<sub>calc</sub> | RI<sub>db</sub> | Compounds                  | Percent Composition |
|-------------------|-----------------|----------------------------|---------------------|
| RI<sub>calc</sub> | RI<sub>db</sub> | B.e. | B.r. | B.y. |
| 930               | 924             | α-Thujene                   | -                   | 0.1 | 0.6 |
| 939               | 932             | α-Pinene                    | 3.2                 | 2.9 | 6.0 |
| 955               | 946             | Camphene                    | 0.2                 | 0.2 | 0.2 |
| 979               | 969             | Sabinene                    | 0.1                 | 0.6 | 1.9 |
| 984               | 974             | β-Pinene                    | 0.6                 | 2.7 | 4.7 |
| 992               | 988             | Myrcene                     | 0.5                 | 0.4 | 0.8 |
| 1010              | 1002            | α-Phellandrene              | 0.1                 | -   | 0.1 |
| 1022              | 1014            | α-Terpinene                 | -                   | 0.5 | 1.5 |
| 1030              | 1020            | α-Cymene                    | -                   | 0.3 | 0.8 |
| 1034              | 1024            | Limonene                    | 0.2                 | 0.8 | 1.2 |
| 1035              | 1025            | β-Phellandrene              | -                   | 0.1 | 0.6 |
| 1039              | 1032            | (Z)-β-Ocimene               | 26.1                | -   | 0.1 |
| 1049              | 1044            | (E)-β-Ocimene               | 3.6                 | 0.5 | -   |
| 1063              | 1054            | γ-Terpine                   | -                   | 0.9 | 2.6 |
| 1094              | 1086            | Terpinolene                 | -                   | 0.4 | 0.8 |
| 1117              | 1113            | (E)-4,8-Dimethyl-1,3,7-triene| -                   | -   | 0.2 |
| 1131              | 1128            | allo-Ocimene                | 0.6                 | -   | -   |
| 1188              | 1174            | Terpinen-4-ol               | -                   | 0.5 | 1.8 |
| 1200              | 1186            | α-Terpineol                 | -                   | -   | 0.2 |
| 1294              | 1287            | Bornyl acetate              | 0.3                 | -   | -   |
| 1348              | 1335            | δ-Elemene                   | 1.5                 | 0.3 | 0.3 |
| 1360              | 1345            | α-Cubebeene                 | -                   | 0.3 | -   |
| 1365              | 1359            | Neryl acetate               | -                   | -   | 0.2 |
| 1384              | 1373            | α-Ylangene                  | -                   | 0.1 | -   |
| 1386              | 1387            | β-Cubebeene                 | -                   | -   | 0.1 |
| 1389              | 1374            | α-Copaene                   | 0.3                 | 0.7 | 0.2 |
| 1397              | 1390            | 7-epi-Sesquithujene         | 0.5                 | 0.7 | 1.0 |
| 1399              | 1387            | β-Bourbonene                | -                   | 0.9 | -   |
| 1404              | 1389            | β-Elemene                   | 1.0                 | 1.0 | 0.6 |
| 1425              | 1411            | cis-α-Bergamotene           | -                   | 0.4 | 0.4 |
| RI_{calc} | RI_{db} | Compounds                      | Percent Composition |
|----------|---------|--------------------------------|---------------------|
|          |         |                                | B.e.    | B.r.  | B.y. |
| 1428     | 1409    | \(\alpha\)-Gurjunene           | -       | -     | 0.3  |
| 1437     | 1417    | (E)-Caryophyllene               | 18.3    | 22.5  | 16.2 |
| 1446     | 1432    | trans-\(\alpha\)-bergamotene   | 0.5     | 1.2   | 1.1  |
| 1452     | 1437    | \(\alpha\)-Guaiene             | -       | 0.4   | 0.4  |
| 1457     | 1439    | Aromadendrene                   | 0.7     | 1.5   | 1.8  |
| 1460     | 1440    | (Z)-\(\beta\)-Farnesene        | 0.3     | 0.2   | 0.5  |
| 1466     | 1448    | cis-Muurolo-3,5-diene           | -       | 0.2   | -    |
| 1471     | 1452    | \(\alpha\)-Humulene            | 2.6     | 13.4  | 9.9  |
| 1479     | 1464    | 9-\textit{epi-}(E)-Caryophyllene| 0.4     | 0.5   | 21.2 |
| 1488     | 1481    | \(\gamma\)-Curcumene           | -       | -     | 0.2  |
| 1490     | 1478    | \(\gamma\)-Muuroloene          | 0.1     | 1.9   | 0.3  |
| 1494     | 1483    | \(\alpha\)-Amorphene           | -       | 0.6   | -    |
| 1498     | 1484    | Germacrene D                    | 2.7     | 20.3  | 1.1  |
| 1504     | 1489    | \(\beta\)-Selinene             | -       | -     | 0.2  |
| 1505     | 1492    | \(\delta\)-Selinene            | -       | 0.4   | 0.2  |
| 1507     | 1490    | 9-Aromadendrene                 | -       | -     | 0.9  |
| 1512     | 1505    | (E,E)-\(\alpha\)-Farnesene     | -       | 1.4   | -    |
| 1512     | 1496    | Viridiflore                     | -       | 2.4   | 2.0  |
| 1514     | 1500    | Bicyclogermacon                | 30.5    | 8.6   | 8.4  |
| 1520     | 1514    | \(\beta\)-Curcumene            | -       | -     | 0.2  |
| 1521     | 1511    | \(\delta\)-Amorphene           | 0.1     | -     | -    |
| 1522     | 1509    | \(\alpha\)-Bulnesene           | -       | -     | 0.3  |
| 1530     | 1513    | \(\gamma\)-Cadinene            | 0.1     | 0.8   | 0.2  |
| 1537     | 1522    | \(\delta\)-Cadinene            | 0.5     | 2.9   | 0.5  |
| 1540     | 1528    | Zonarene                       | -       | 0.2   | -    |
| 1547     | 1533    | trans-Cadina-1,4-diene          | -       | 0.2   | -    |
| 1552     | 1537    | \(\alpha\)-Cadinene            | -       | 0.2   | -    |
| 1562     | 1548    | Elemol                         | 0.2     | -     | -    |
| 1571     | 1561    | (E)-Nerolidol                  | -       | 0.2   | 1.4  |
| 1577     | 1559    | Germacrene B                   | 0.2     | -     | -    |
| 1588     | 1567    | Palustrol                      | -       | -     | 0.4  |
| 1599     | 1577    | Spathulenol                    | 0.9     | 0.6   | 1.0  |
| 1604     | 1592    | Viridiflorol                   | -       | 0.4   | 1.2  |
| 1605     | 1582    | Caryophyllene oxide            | 0.6     | 0.4   | -    |
| 1612     | 1595    | Cubeban-11-ol                  | -       | 0.6   | -    |
| 1615     | 1600    | Guaiol                         | 0.3     | -     | 1.0  |
| 1621     | 1600    | Rosifoliol                     | -       | 0.2   | 0.3  |
| 1625     | 1602    | Ledol                          | -       | -     | 1.1  |
| 1632     | 1608    | Humulene epoxide II            | -       | 0.2   | 0.2  |
| 1642     | 1637    | 5-Guaiene-11-ol                | -       | -     | 0.2  |
| 1658     | 1640    | \textit{epi-}\(\alpha\)-Muurolo| -       | 0.2   | -    |
| 1659     | 1638    | \textit{epi-}\(\alpha\)-Cadinol| -       | 0.2   | -    |
| 1670     | 1652    | \(\alpha\)-Eudesmol            | 0.1     | -     | -    |
| 1673     | 1652    | \(\alpha\)-Cadinol             | 0.1     | 0.5   | -    |
| 1674     | 1662    | 7-\textit{epi-}\(\alpha\)-Eudesmol| 0.3   | -     | -    |
| 1683     | 1670    | \textit{epi-}\(\beta\)-Bisabolol| -       | -     | 0.1  |
| 1759     | 1732    | Zerumbone                      | 0.1     | -     | -    |

Monoterpene hydrocarbons 35.2 10.4 21.9
Oxygenated monoterpeneoids 0.3 0.5 2.2
Sesquiterpene hydrocarbons 60.3 84.2 68.5
Oxygenated sesquiterpenoids 2.6 3.5 6.9
Others 0.0 0.0 0.2

Total identified 98.4 98.6 99.7

RI_{calc} = Retention index determined with respect to a homologous series of n-alkanes on a HP-5ms column,
RI_{db} = Retention index from the databases [35–37]. B.e. = Beilschmiedia erythrophloia, B.r. = Beilschmiedia robusta, B.y. = Beilschmiedia yunnanensis.
The major components in *B. erythrophloia* essential oil were bicyclogermacrene (30.5%), (Z)-β-ocimene (26.1%), and (E)-caryophyllene (18.3%). While qualitatively similar, there are notable differences between the essential oil from Vietnam in this work and that reported by Su and Ho from Taiwan [17]; the sample from Taiwan was rich in α-humulene (21.9%) compared to that from Vietnam (only 2.6%), but poor in bicyclogermacrene (1.2%) compared to that from Vietnam.

Both *B. robusta* and *B. yunnanensis* leaf oils were rich in (E)-caryophyllene (22.5% and 16.2%, respectively), α-humulene (13.4% and 9.9%), and bicyclogermacrene (8.6% and 8.4%). The leaf oil of *B. robusta* had a high concentration of germacrene D (20.3%), while *B. yunnanensis* oil was rich in 9-epi-(E)-caryophyllene (21.2%).

The leaf essential compositions of *C. concinna* (from two locations), *C. impressa*, and *C. infectoria* are listed in Table 3. Sesquiterpene hydrocarbons were abundant in both *C. impressa* and *C. infectoria* leaf essential oils, while oxygenated sesquiterpenoids were abundant in *C. concinna* essential oil from Nam Dong and monoterpene hydrocarbons dominated the leaf oil of *C. concinna* from Pu Hoat.

**Table 3.** Chemical compositions of the leaf essential oils of *Cryptocarya* species collected in Vietnam.

| RI<sub>calc</sub> | RI<sub>db</sub> | Compound                       | C.c. N.D. | C.c. P.H. | C.im. | C.in. |
|------------------|----------------|--------------------------------|-----------|-----------|-------|-------|
| 930              | 927            | α-thujene                      | tr        | 0.1       | -     | -     |
| 931              | 932            | α-Piene                        | 8.2       | 26.7      | 4.1   | 0.8   |
| 945              | 948            | α-Fenchene                     | tr        | -         | -     | -     |
| 955              | 953            | Camphene                       | 0.2       | 0.4       | 0.3   | 0.6   |
| 967              | 961            | Benzaldehyde                   | -         | -         | -     | -     |
| 970              | 971            | Sabinene                       | tr        | -         | -     | -     |
| 975              | 978            | β-Piene                        | 9.0       | 31.3      | 2.7   | 0.2   |
| 986              | 989            | Myrcene                        | 3.9       | 11.1      | 3.9   | -     |
| 1010             | 1002           | α-Phellandrene                 | -         | -         | 2.5   | -     |
| 1012             | 1009           | δ-3-Carene                     | 0.1       | -         | 0.2   | -     |
| 1027             | 1025           | p-Cymene                       | 0.1       | -         | 0.6   | -     |
| 1027             | 1030           | Limonene                       | 2.0       | 2.8       | 0.9   | 0.2   |
| 1028             | 1031           | β-Phellandrene                 | tr        | 0.3       | -     | -     |
| 1033             | 1034           | (Z)-β-Ocimene                  | tr        | 0.6       | 0.3   | -     |
| 1043             | 1046           | (E)-β-Ocimene                  | 0.2       | 8.8       | 4.0   | -     |
| 1063             | 1054           | γ-Terpinene                    | -         | 0.1       | -     | -     |
| 1094             | 1086           | Terpinolene                    | -         | 0.1       | 0.4   | -     |
| 1096             | 1098           | Perillene                      | 0.1       | -         | -     | -     |
| 1098             | 1101           | α-Piene oxide                  | 0.2       | -         | -     | -     |
| 1101             | 1095           | Linalool                       | -         | 1.1       | 3.4   | -     |
| 1117             | 1116           | (E)-4,8-Dimethylinona-1,3,7-triene | -     | -         | 0.7   | -     |
| 1137             | 1139           | Nopinone                       | 0.1       | -         | -     | -     |
| 1139             | 1141           | *trans*-Pinocarveol            | 0.3       | -         | -     | -     |
| 1144             | 1145           | *trans*-Verbenol               | 0.1       | -         | -     | -     |
| 1161             | 1164           | Pinocarvone                    | 0.1       | -         | -     | -     |
| 1194             | 1195           | Myrtenol                       | 0.3       | -         | -     | -     |
| 1206             | 1201           | Decanal                        | -         | -         | 1.6   | -     |
| 1299             | 1300           | Tridecanes                     | -         | -         | 0.2   | -     |
| 1308             | 1305           | Undecanal                      | -         | -         | 0.2   | -     |
| 1332             | 1333           | δ-Elemene                      | 0.9       | 0.2       | 0.7   | 5.1   |
| 1344             | 1348           | α-Cubebene                     | 0.2       | -         | 0.1   | 0.3   |
| 1366             | 1371           | α-Ylangene                     | 0.4       | -         | -     | -     |
| 1367             | 1356           | Eugenol                        | -         | -         | -     | 0.1   |
| 1373             | 1375           | α-Copaene                      | 0.5       | -         | 0.5   | 0.8   |
| 1381             | 1382           | β-Bourbonene                   | 0.2       | -         | -     | 0.3   |
| 1384             | 1373           | α-Ylangene                     | -         | -         | -     | 0.4   |
| 1385             | 1387           | β-Cubebene                     | 0.1       | -         | -     | -     |
| 1387             | 1390           | β-Elemene                      | 0.9       | 0.1       | 1.2   | 2.1   |
**Table 3. Cont.**

| RI<sub>calc</sub> | RI<sub>db</sub> | Compound | Percent Composition |
|------------------|----------------|----------|---------------------|
|                  |                |          | C.c. N.D. | C.c. P.H. | C.im. | C.in. |
| 1412             | 1408           | Dodecanal | -         | -         | 10.8  | -     |
| 1417             | 1417           | (E)-Caryophyllene | 12.2 | 5.3 | 10.8 | 1.7 |
| 1419             | 1421           | (E)-α-Ionone | tr       | -         | -     | -     |
| 1424             | 1430           | γ-Maaliene | 0.2      | -         | -     | -     |
| 1427             | 1430           | β-Copaene  | 0.3      | -         | -     | -     |
| 1428             | 1426           | α-Gurjunene | -        | -         | 0.4   | -     |
| 1430             | 1432           | trans-α-Bergamotene | 1.6  | - | 0.9  | -    |
| 1436             | 1438           | Aromadendrene | 1.5 | 0.8 | 1.8  | -    |
| 1445             | 1437           | β-Gurjunene | -        | -         | 0.8   | -     |
| 1449             | 1455           | Valerena-4,7(11)-diene | 0.1  | - | -    | -    |
| 1453             | 1454           | α-Humulene | 1.5      | 0.6       | 6.3   | 1.9  |
| 1454             | 1442           | α-Maaliene | -        | -         | 0.2   | -     |
| 1456             | 1447           | Guai-a-6,9-diene  | -       | -         | 0.6   | -     |
| 1457             | 1458           | allo-Aromadendrene | 0.1  | - | -    | -    |
| 1459             | 1454           | Selina-5,11-diene | -      | -         | 0.2   | -     |
| 1463             | 1463           | cis-Murola-4(14),5-diene | -  | - | 0.1  | -    |
| 1466             | 1454           | cis-Murola-3,5-diene | -      | -         | -     | 0.2  |
| 1472             | 1475           | γ-Murolene | 1.6      | 0.4       | 0.7   | 1.3  |
| 1476             | 1482           | α-Amorphene | 0.2      | -         | 0.7   | 0.7  |
| 1478             | 1480           | Germaconene D | 0.2    | 1.3     | 2.5   | 55.5 |
| 1479             | 1470           | 9-epi-(E)-caryophyllene | -     | 0.2 | 0.6  | 0.3  |
| 1480             | 1477           | trans-Cadina-1(6),4-diene | -   | -     | 0.3   | -    |
| 1481             | 1478           | γ-Gurjunene | 0.1      | -         | -     | -     |
| 1486             | 1489           | β-Selinene | 0.5      | -         | 0.5   | -     |
| 1488             | 1491           | Viridi-florene | 0.1    | -     | -     | -    |
| 1489             | 1490           | γ-Amorphene | 0.3      | -         | -     | -     |
| 1493             | 1497           | α-Selinene  | 0.6      | -         | -     | -     |
| 1495             | 1497           | α-Murolene | 0.4      | -         | -     | -     |
| 1504             | 1508           | β-Bisabolene | 0.2    | -        | -     | -     |
| 1505             | 1497           | δ-Selinene  | -        | -         | 0.7   | -     |
| 1509             | 1496           | γ-Amorphene | -        | -         | 0.3   | -     |
| 1512             | 1515           | Cubebol    | 0.2      | -         | -     | -     |
| 1512             | 1517           | (E,E)-α-Farnesene | -     | -     | 7.9   | -    |
| 1514             | 1511           | Bicyclogermacrene | -   | -     | 18.7  | 11.4 |
| 1515             | 1518           | δ-Cadinene | 0.7      | 0.7       | 1.1   | -    |
| 1518             | 1519           | trans-Calamenene | 0.3  | -     | -     | -    |
| 1520             | 1512           | γ-Cadinene | 1.3      | 0.4       | 0.3   | -    |
| 1521             | 1515           | δ-Amorphene | -        | -         | 0.2   | 0.7  |
| 1534             | 1538           | α-Cadinene | 0.2      | -         | -     | 0.2  |
| 1538             | 1541           | α-Calacorene | 0.4     | -        | -     | -    |
| 1538             | 1531           | cis-Calamene | -     | -        | 0.2   | -    |
| 1546             | 1549           | α-Elemol    | 0.1      | -         | -     | 0.2  |
| 1547             | 1540           | trans-Cadina-1,4-diene | -   | -     | 0.1   | -    |
| 1548             | 1551           | Iso-caryophyllene oxide | 0.9  | -     | -     | -    |
| 1556             | 1560           | Germacrene B | 0.1      | -     | 0.7   | 0.6  |
| 1558             | 1560           | (E)-Nerolidol | 0.2      | -     | 0.7   | 0.1  |
| 1559             | 1560           | β-Calacorene | 0.3      | -        | -     | -    |
| 1560             | 1551           | Selina-3,7(11)-diene | -   | -     | 0.5   | -    |
| 1565             | 1566           | 1,5-Epoxy-salvial-4(14)-ene | 0.6  | -     | -     | -    |
| 1575             | 1578           | Spathulenol | 12.3     | 1.1       | 1.4   | 0.1  |
| 1580             | 1587           | Caryophyllene oxide | 21.2  | 0.4   | 0.4   | 0.2  |
| 1585             | 1590           | Globulol    | 0.7      | -        | -     | -    |
| 1587             | 1579           | Dendrolasin | -        | -         | 0.2   | -    |
| 1594             | 1593           | Scapanol    | -        | -         | 0.2   | -    |
Table 3. Cont.

| RI<sub>calc</sub> | RI<sub>db</sub> | Compound | Percent Composition |
|------------------|-----------------|----------|---------------------|
|                  |                 |          | C.c. N.D. | C.c. P.H. | C.im. | C.in. |
| 1597             | 1594            | Viridiflorol 0.4 | - | 0.4 | - | - |
| 1604             | 1612            | 5-epi-7-epi-β-Eudesmol 0.2 | - | - | - | - |
| 1607             | 1613            | Humulene epoxide II 1.5 | - | 0.3 | - | - |
| 1612             | 1601            | Cubeban-11-ol - | - | 0.4 | - | - |
| 1614             | 1611            | Tetradecanal - | - | 1.0 | - | - |
| 1621             | 1615            | Rosifoliol - | - | 0.4 | - | - |
| 1622             | 1624            | Muurola-4,10(14)-dien-1β-ol 0.2 | - | - | - | - |
| 1625             | 1629            | iso-Spathulenol 1.8 | - | - | - | - |
| 1630             | 1633            | Caryophylla-4(12),8(13)-dien-5α-ol 0.9 | - | - | - | - |
| 1631             | 1636            | Caryophylla-4(12),8(13)-dien-5β-ol 0.6 | - | - | - | - |
| 1639             | 1640            | β-Cadinol 0.2 | 0.4 | - | 0.3 | - |
| 1641             | 1644            | μ-Muurolol 0.2 | - | - | 0.2 | - |
| 1642             | 1645            | 5-Guaien-11-ol - | - | 0.2 | - | - |
| 1644             | 1645            | δ-Cadinol 0.4 | - | - | - | - |
| 1646             | 1635            | Muurola-4,10(14)-dien-1β-ol - | - | - | 0.1 | - |
| 1652             | 1656            | β-Eudesmol 0.7 | - | - | - | - |
| 1653             | 1655            | α-Cadinol 0.9 | - | 0.1 | 0.4 | - |
| 1654             | 1661            | cis-Calamenen-10-ol 0.4 | - | - | - | - |
| 1656             | 1660            | Selin-11-en-4α-ol 0.3 | - | - | - | - |
| 1662             | 1662            | 9-Methoxycalamene 0.4 | - | - | - | - |
| 1668             | 1666            | 14-Hydroxy-9-epi-(E)-Caryophyllene 0.8 | - | - | - | - |
| 1955             | 1958            | Palmitic acid 0.2 | - | - | - | - |
| 2116             | 2114            | Phytol - | - | 0.4 | - | - |
|                  |                 | Monoterpane hydrocarbons 23.7 | 82.3 | 19.9 | 1.8 | - |
|                  |                 | Oxygenated monoterpenoids 1.1 | 1.1 | 0.0 | 3.4 | - |
|                  |                 | Sesquiterpane hydrocarbons 28.1 | 10.0 | 57.6 | 86.5 | - |
|                  |                 | Oxygenated sesquiterpenoids 46.1 | 1.9 | 4.5 | 1.8 | - |
|                  |                 | Diterpenoids 0.0 | 0.0 | 0.4 | 0.0 | - |
|                  |                 | Others 0.3 | 0.0 | 14.5 | 0.2 | - |
|                  |                 | Total Identified 99.2 | 95.3 | 96.9 | 93.7 | - |

RI<sub>calc</sub> = Retention index determined with respect to a homologous series of n-alkanes on a HP-5ms column, RI<sub>db</sub> = Retention index from the databases [35–37], C.c. N.D. = Cryptocarya concinna from Nam Dong, C.c. P.H. = Cryptocarya concinna from Pu Hoat, C.im. = Cryptocarya impressa, C.in. = Cryptocarya infectoria, tr = trace.

The leaf essential oils of C. concinna from two different collection sites were qualitatively similar, but quantitatively different. That is, the abundant components in the Nam Dong sample were also observed in the Pu Hoat sample, and vice versa. Thus, for example, α-pinene, β-pinene, and myrcene were abundant in the Pu Hoat sample (26.7%, 31.3%, and 11.1%, respectively) but were found in lower concentrations in the sample from Nam Dong (8.2%, 9.0%, and 3.9%). Conversely, the sesquiterpenoids, (E)-caryophyllene, spathulenol, and caryophyllene oxide were abundant in the sample from Nam Dong (12.2%, 12.3%, and 21.2%, respectively), but less concentrated in the Pu Hoat sample (5.3%, 1.1%, and 0.4%).

The major components of the leaf essential oil of C. impressa were bicyclogermacrene (18.7%), (E)-caryophyllene (10.8%), dodecanal (10.8%), (E,E)-α-farnesene (7.9%), and α-humulene (6.3%). Germacrene D (55.5%) dominated the essential oil composition of C. infectoria, which was also composed of bicyclogermacrene (11.4%) and δ-elemene (5.1%) as major components.

The chemical compositions of the leaf essential oils of L. viridis, M. balansae, M. grandifolia, N. ellisoidea, and P. angustifolia are compiled in Table 4.
Table 4. Chemical compositions of the leaf essential oils of *Litsea viridis*, *Machilus balansae*, *Machilus grandifolia*, *Neolitsea ellipsoidea*, and *Phoebe angustifolia* collected in Vietnam.

| RI<sub>calc</sub> | RI<sub>db</sub> | Compound                        | Percent Composition |
|------------------|-----------------|----------------------------------|---------------------|
|                  |                 |                                  | L.v.    | M.b. | M.g. | N.e. | P.a. |
| 921              | 923             | Tricyclene                       | -       | -    | -    | -    | 0.1  |
| 923              | 927             | α-Thujene                        | -       | -    | -    | -    | 0.1  |
| 934              | 933             | α-Pinene                         | 11.1    | 4.4  | 0.3  | 0.2  | 26.9 |
| 949              | 948             | α-Fenchene                       | 0.1     | -    | -    | -    | 0.1  |
| 950              | 953             | Camphene                         | 0.7     | 0.3  | 0.3  | -    | 6.1  |
| 971              | 972             | Sabinene                         | -       | -    | -    | -    | 0.1  |
| 979              | 978             | β-Pinene                         | 8.3     | 1.2  | 0.4  | 0.2  | 20.8 |
| 979              | 978             | 1-Octen-3-ol                     | -       | -    | 0.1  | -    | -    |
| 984              | 984             | 6-Methylhept-5-en-2-one          | -       | -    | -    | -    | -    |
| 990              | 991             | Myrcene                          | 0.4     | 0.4  | -    | 0.5  | 1.5  |
| 1008             | 1006            | α-Phellandrene                   | 0.1     | -    | -    | -    | 0.1  |
| 1022             | 1014            | α-Terpine                         | 0.2     | -    | -    | -    | -    |
| 1026             | 1025            | p-Cymene                         | 0.2     | 1.0  | -    | 5.0  |
| 1030             | 1030            | Limonene                         | 1.8     | 0.4  | 1.3  | 0.4  | 3.1  |
| 1030             | 1031            | β-Phellandrene                   | -       | 0.4  | -    | -    | 0.2  |
| 1031             | 1032            | 1,8-Cineole                      | -       | -    | 0.1  | -    | 0.4  |
| 1034             | 1034            | (Z)-β-Ocimene                    | 0.1     | 0.1  | -    | 3.7  | 0.3  |
| 1046             | 1046            | (E)-β-Ocimene                    | 0.3     | 4.5  | -    | 87.6 | 0.1  |
| 1063             | 1054            | γ-Terpine                         | 0.5     | -    | -    | -    | -    |
| 1069             | 1069            | cis-Linalool oxide (furanoid)    | -       | -    | 0.4  | -    | -    |
| 1086             | 1086            | trans-Linalool oxide (furanoid)  | -       | -    | 0.4  | -    | -    |
| 1089             | 1086            | Terpinolene                      | 0.4     | -    | -    | -    | tr   |
| 1090             | 1093            | p-Cymenene                       | -       | -    | -    | -    | 0.1  |
| 1099             | 1101            | α-Pinen oxide                    | -       | -    | -    | -    | 0.1  |
| 1100             | 1101            | Linalool                         | -       | 0.1  | -    | 3.3  | 0.1  |
| 1105             | 1100            | Nonanal                          | 0.2     | 0.2  | -    | -    | -    |
| 1117             | 1113            | (E)-4,8-Dimethylmona-1,3,7-triene| 0.4     | 0.4  | -    | -    | -    |
| 1119             | 1119            | endo-Fenchol                     | -       | -    | 0.1  | -    | 0.1  |
| 1124             | 1124            | cis-p-Menth-2-en-1-ol             | -       | -    | 0.1  | -    | -    |
| 1141             | 1141            | trans-Pinocarveol                | -       | -    | 0.1  | -    | 0.3  |
| 1142             | 1142            | trans-p-Menth-2-en-1-ol           | -       | -    | 0.1  | -    | -    |
| 1143             | 1140            | (E)-Myroxide                     | -       | -    | 0.2  | -    | -    |
| 1145             | 1145            | trans-Verbenol                   | -       | -    | -    | -    | 0.1  |
| 1155             | 1156            | Camphene hydrate                 | -       | -    | 0.1  | -    | 0.1  |
| 1163             | 1164            | Pinocarvone                      | -       | -    | -    | -    | 0.1  |
| 1172             | 1173            | Borneol                          | -       | -    | 0.1  | -    | 0.5  |
| 1183             | 1184            | Terpinen-4-ol                    | 0.2     | 0.1  | -    | 0.1  | -    |
| 1186             | 1184            | (3Z)-Hexenyl butanoate           | -       | -    | 0.3  | -    | -    |
| 1188             | 1187            | Cryptone                         | -       | -    | 0.5  | -    | -    |
| 1196             | 1195            | α-Terpine                         | -       | -    | 0.3  | -    | 0.6  |
| 1206             | 1208            | Decanal                          | 14.4    | -    | -    | -    | 0.1  |
| 1220             | 1223            | trans-Cardovel                   | -       | -    | 0.1  | -    | -    |
| 1245             | 1246            | Carvone                          | -       | -    | 0.1  | -    | -    |
| 1275             | 1275            | trans-Ascaridol glycol           | -       | -    | 0.1  | -    | -    |
| 1283             | 1285            | Bornyl acetate                   | -       | -    | -    | -    | 1.4  |
| 1299             | 1300            | Tridecane                        | -       | 0.3  | -    | -    | -    |
| 1330             | 1328            | iso-Dihydro carvyl acetate       | -       | -    | -    | -    | 0.2  |
| 1348             | 1335            | δ-Elemene                        | -       | 1.7  | -    | -    | -    |
| 1358             | 1361            | Neryl acetate                    | -       | -    | -    | -    | 0.1  |
| 1360             | 1345            | α-Cubebene                       | -       | 0.1  | -    | -    | -    |
| 1367             | 1367            | Cyclosativene                    | -       | 0.2  | -    | -    | -    |
| RI<sub>calc</sub> | RI<sub>db</sub> | Compound                        | Percent Composition |  |  |  |  |  |
|-----------------|----------------|---------------------------------|---------------------|---|---|---|---|---|
| 1377            | 1378           | Geranyl acetate                 | -                   | - | 0.1 | - | - |
| 1377            | 1372           | <i>iso</i>-Ledene                | 0.3                 | - | - | - | 0.1 |
| 1378            | 1375           | α-Copaene                       | 0.6                 | 0.5 | 1.7 | - | 0.3 |
| 1390            | 1379           | Methyl (<i>E</i>)-cinnamate      | 1.5                 | - | - | - | - |
| 1395            | 1390           | β-Elemene                       | 1.9                 | 1.0 | - | 0.3 | 0.1 |
| 1404            | 1406           | α-Gurjunene                     | -                   | - | 0.1 | - | - |
| 1412            | 1412           | Dodecanal                       | 2.0                 | - | - | - | - |
| 1418            | 1416           | <i>cis</i>-α-Bergamotene         | 0.6                 | - | - | - | 0.2 |
| 1424            | 1417           | (<i>E</i>)-Caryophyllene         | 0.3                 | 8.5 | 0.1 | 0.4 | 5.3 |
| 1425            | 1430           | γ-Maaliene                      | -                   | - | - | - | 0.1 |
| 1428            | 1422           | α-Gurjunene                     | -                   | 0.5 | - | - | - |
| 1434            | 1432           | β-Copaene                       | -                   | 0.2 | - | - | - |
| 1436            | 1434           | β-Gurjunene (= Calarene)         | -                   | 0.6 | - | - | 0.1 |
| 1438            | 1432           | <i>trans</i>-α-Bergamotene      | 0.6                 | 0.6 | - | - | 0.8 |
| 1442            | 1438           | α-Maaliene                      | -                   | 0.3 | - | - | 0.1 |
| 1443            | 1438           | Aromadendrene                   | 3.0                 | 4.5 | 1.0 | 0.3 | 1.8 |
| 1444            | 1445           | Selina-5,11-diene                | -                   | - | 0.1 | - | 0.2 |
| 1445            | 1445           | <i>epi</i>-β-Santalone          | -                   | - | - | - | 0.1 |
| 1446            | 1447           | γ-Elemene                       | 1.0                 | - | - | - | - |
| 1453            | 1453           | <i>cis</i>-Muurola-3,5-diene     | 0.2                 | 0.2 | - | - | - |
| 1454            | 1454           | α-Humulene                      | 0.9                 | 1.4 | - | - | 0.6 |
| 1455            | 1452           | (<i>E</i>)-β-Farnesene          | 0.3                 | - | - | - | 0.3 |
| 1457            | 1459           | β-Santalone                     | -                   | - | - | - | 0.3 |
| 1458            | 1458           | <i>allo</i>-Aromadendrene       | -                   | - | 0.2 | - | 0.1 |
| 1466            | 1467           | <i>trans</i>-Muurola-3,5-diene   | -                   | 0.5 | - | - | - |
| 1471            | 1476           | γ-Gurjunene                     | -                   | - | - | - | 0.1 |
| 1471            | 1476           | Selina-4,11-diene                | -                   | - | 0.4 | - | - |
| 1479            | 1478           | γ-Muurolene                     | 0.5                 | 0.8 | 0.6 | 0.1 | 0.1 |
| 1479            | 1474           | 9-<i>epi</i>-(<i>E</i>)-caryophyllene | 0.8               | 0.8 | - | - | - |
| 1482            | 1483           | <i>trans</i>-β-Bergamotene      | -                   | - | - | - | 0.2 |
| 1485            | 1482           | ar-Curcumene                    | 0.4                 | - | - | - | tr |
| 1486            | 1482           | α-Amorphene                     | -                   | 0.6 | 0.1 | - | - |
| 1488            | 1484           | γ-Curcumene                     | 0.4                 | - | - | - | - |
| 1489            | 1491           | Viridiflorene                   | 0.2                 | - | - | - | 1.2 |
| 1493            | 1487           | β-Selinene                      | 1.2                 | 0.4 | 2.7 | 0.6 | 0.1 |
| 1497            | 1497           | α-Muurolene                     | -                   | - | 0.5 | - | 0.1 |
| 1498            | 1501           | (<i>Z</i>)-α-Bisabolene          | -                   | - | - | - | 0.1 |
| 1498            | 1496           | Germacrene D                    | 1.0                 | 3.1 | - | 0.1 | - |
| 1503            | 1497           | Bicyclogermacrene               | 25.5                | 41.5 | - | - | 1.3 |
| 1503            | 1497           | α-Selinene                      | -                   | - | 1.3 | 0.5 | - |
| 1505            | 1500           | δ-Selinene                      | 0.9                 | 0.5 | - | - | - |
| 1506            | 1508           | β-Bisabolene                    | -                   | - | - | - | 0.3 |
| 1508            | 1511           | (<i>Z</i>)-γ-Bisabolene          | -                   | - | - | - | 0.1 |
| 1512            | 1511           | (<i>E</i>)-(E)-α-Farnesene      | -                   | 1.8 | - | - | - |
| 1517            | 1512           | γ-Cadinene                      | 0.3                 | 0.3 | 0.5 | - | 0.2 |
| 1520            | 1519           | <i>trans</i>-Calamenene         | -                   | - | 0.8 | - | 0.1 |
| 1520            | 1517           | β-Curcumene                     | 0.5                 | - | - | - | - |
| 1521            | 1516           | δ-Amorphene                     | 0.2                 | 0.3 | - | - | - |
| 1523            | 1518           | δ-Cadinene                      | 0.9                 | 0.7 | 0.2 | 0.2 | 0.2 |
| 1542            | 1531           | (<i>E</i>)-(E)-γ-Bisabolene      | 1.0                 | - | - | - | - |
| 1547            | 1551           | Elemicin                        | -                   | - | 1.2 | - | - |
| 1550            | 1547           | (<i>E</i>)-α-Bisabolene         | 0.4                 | - | - | - | - |
| RI<sub>calc</sub> | RI<sub>db</sub> | Compound | Percent Composition |
|-----------------|----------------|----------|---------------------|
|                 |                |          | L.v. | M.b. | M.g. | N.e. | P.a. |
| 1555            | 1555           | (Z)-Dihydronerolidol | -   | -   | 2.4  | -   | -   |
| 1560            | 1545           | Selina-3,7(11)-diene  | 0.4 | -   | -   | -   | -   |
| 1564            | 1561           | (E)-Nerolidol          | 1.1 | 8.7 | 22.7 | -   | 3.9 |
| 1568            | 1568           | Maaliol               | -   | -   | -   | -   | 0.1 |
| 1569            | 1568           | Palustrol              | -   | -   | -   | -   | 0.1 |
| 1569            | 1570           | (E)-Dihydronerolidol   | -   | -   | 2.8  | -   | -   |
| 1575            | 1575           | Caryolan-8-ol          | -   | -   | 0.8  | -   | -   |
| 1577            | 1568           | Germacrene B           | 1.3 | 0.8 | -   | -   | -   |
| 1578            | 1578           | Spathulenol            | 0.9 | 0.6 | -   | 0.6 | 5.4 |
| 1585            | 1590           | Globulol               | -   | -   | 10.2 | -   | 1.7 |
| 1589            | 1587           | Caryophyllene oxide    | -   | -   | 3.7  | 0.1 | 1.5 |
| 1596            | 1594           | Viridiflorol           | 0.4 | 1.6 | 0.7  | -   | 0.7 |
| 1601            | 1599           | Cubeban-11-ol          | -   | 1.0 | 0.6  | -   | 0.2 |
| 1604            | 1605           | Ledol                  | -   | -   | 0.7  | -   | 0.1 |
| 1609            | 1613           | Humulene epoxide II    | -   | -   | 1.5  | -   | 0.1 |
| 1611            | 1609           | Rosifoliol             | 0.4 | 0.4 | 0.2  | -   | 0.2 |
| 1615            | 1617           | Guaiol                 | 0.8 | -   | -   | -   | -   |
| 1627            | 1631           | 1-epi-Cubenol          | -   | -   | 0.8  | -   | -   |
| 1632            | 1629           | iso-Spathulenol        | -   | -   | -   | -   | 0.4 |
| 1642            | 1637           | 5-Guaien-11-ol         | -   | 0.5 | -   | -   | -   |
| 1646            | 1645           | α-Muurol (= δ-Cadinol) | -   | -   | 1.5  | -   | 0.1 |
| 1647            | 1643           | α-Cadinol              | -   | 0.2 | 0.7  | -   | 0.3 |
| 1649            | 1645           | α-Muurol               | -   | 0.1 | 1.3  | -   | 0.1 |
| 1655            | 1655           | α-Cadinol              | -   | 0.5 | 0.4  | 2.9 | -   | 0.2 |
| 1658            | 1660           | Selin-11-en-4α-ol      | -   | 0.3 | 6.7  | -   | -   |
| 1665            | 1670           | trans-Calamenen-10-ol  | -   | -   | 1.3  | -   | -   |
| 1671            | 1665           | β-Eudesmol             | 0.6 | -   | -   | -   | -   |
| 1674            | 1676           | Mustakone              | -   | 0.6 | -   | -   | -   |
| 1674            | 1670           | α-Eudesmol             | 0.3 | -   | -   | -   | -   |
| 1683            | 1672           | epi-β-Bisabolol        | 0.2 | -   | -   | -   | -   |
| 1702            | 1701           | 10-nor-Calamenen-10-one| -   | -   | 0.4  | -   | -   |
|                 | 1700           | Monoterpenes hydrocarbons | 24.2 | 11.3 | 3.3  | 92.6 | 64.5 |
|                 | 1699           | Oxygenated monoterpenoids | 0.2 | 0.0 | 6.2  | 1.5 | 4.3 |
|                 | 1698           | Sesquiterpenes hydrocarbons | 45.6 | 72.2 | 10.6 | 2.5 | 14.8 |
|                 | 1697           | Oxygenated sesquiterpenoids | 5.2 | 13.8 | 62.5 | 0.7 | 15.3 |
|                 | 1696           | Others                 | 18.5 | 0.9 | 1.3  | 0.3 | 0.1 |
|                 |                | Total Identified       | 93.7 | 98.2 | 84.0 | 97.6 | 99.1 |

RI<sub>calc</sub> = Retention index determined with respect to a homologous series of n-alkanes on a HP-5ms column, RI<sub>db</sub> = Retention index from the databases [35–37], L.v. = Litsea viridis, M.b. = Machilus balansae, M.g. = Machilus grandifolia, N.e. = Neolitsea ellippoidea, P.a. = Phoebe angustifolia.

The major components in *L. viridis* leaf essential oil were bicyclogermacrene (25.5%), decanal (14.4%), α-pinene (11.1%), and β-pinene (8.3%). This is the first report on the essential oil from this plant.

Although *M. balansae* and *M. grandifolia* are considered conspecific, the essential oil compositions showed pronounced differences. The leaf oil of *M. balansae* was dominated by bicyclogermacrene (41.5%), which was not detected in the essential oil of *M. grandifolia*. Likewise, the sesquiterpene alcohols (E)-nerolidol and globulol were abundant constituents in *M. grandifolia* (22.7% and 10.2%, respectively), but (E)-nerolidol was much lower in *M. balansae* (8.7%) and globulol was not detected. The taxonomy of these two plants deserves closer scrutiny.

The leaf essential oil of *N. ellipoidea* was dominated by (E)-β-ocimene (87.6%). (E)-β-Ocimene was also found to be the dominant compound (85.6%) in the leaf essential oil of *N. polycarpa* from Vietnam [32], and one of the major components in the leaf essential oils of *N. sericea* from Korea (13.3%) [38], *N. variabilima* from Taiwan (13.4%) [39], and *N. aciculata* from Korea (9.7%) [40]. In contrast,
(E)-β-ocimene was only a minor component in the leaf oils of N. australiensis, N. brassii, or N. dealbata from Australia [41], and N. pallens from India [42], and was not observed in N. foliosa leaf essential oil from India [43].

The leaf essential oil of P. angustifolia from Pù Hoàt Nature Reserve (northern Vietnam) in this study was rich in α-pinene (26.9%), β-pinene (20.8%), spathulenol (5.4%), (E)-caryophyllene (5.3%), and p-cymene (5.0%), which differs markedly from a previous study on the leaf essential oil from Sao La Nature Reserve (central Vietnam). The previous work reported spathulenol (17.0%), palmitic acid (13.0%), sabinene (6.4%), bicyclogermacrene (5.9%), and artemisia triene (5.1%) to be the major components [32]. There is apparently much variation in the volatile components of this plant.

2.2. Larvicidal Activity

The 24-h and 48-h larvicidal activities of Lauraceae leaf essential oils from Vietnam are summarized in Tables 5 and 6. Note that several essential oils were not tested due to lack of sufficient essential oil.

Of the Lauraceae essential oils screened for larvicidal activity, N. ellipsoidea showed the greatest activity against Ae. aegypti with 24-h and 48-h LC₅₀ values of 6.59 and 4.04 µg/mL, respectively. Similar larvicidal activities were observed against Cx. quinquefasciatus (24-h and 48-h LC₅₀ = 7.47 and 4.65 µg/mL) for this essential oil. Interestingly, although the larvicidal activities of C. infectoria leaf essential oil were not as impressive against Ae. aegypti or Ae. albopictus, the essential oil did show much better activity against Cx. quinquefasciatus (24-h LC₅₀ = 10.8 µg/mL), particularly after 48 h of exposure (48-h LC₅₀ = 0.402 µg/mL). Unfortunately, the limited quantities available for several of the essential oils precluded larvicidal screening. However, the larvicidal activity of the untested essential oils will be investigated in future studies.

### Table 5. Twenty-four-hour larvicidal activities of Lauraceae leaf essential oils from Vietnam.

| Laurisilneta species                  | LC₅₀ (µg/mL) | LC₉₀ (µg/mL) | χ²  | p      |
|---------------------------------------|--------------|--------------|-----|--------|
| *Aedes aegypti*                       |              |              |     |        |
| Beilschmiedia erythrophloia           | n.t.         | n.t.         | —   | —      |
| Beilschmiedia robusta                 | 24.29 (22.36–26.76) | 35.22 (31.70–41.19) | 0.1421 | 0.706  |
| Beilschmiedia yunnanensis             | n.t.         | n.t.         | —   | —      |
| Cryptocarya concinna (Nam Dong)       | 32.54 (30.21–35.36) | 42.94 (39.51–47.91) | 0.5537 | 0.758  |
| Cryptocarya concinna (Pu Hoat)        | 23.01 (20.29–25.83) | 40.92 (36.50–47.77) | 9.298 | 0.010  |
| Cryptocarya impressa                   | n.t.         | n.t.         | —   | —      |
| Cryptocarya infectoria                | 21.43 (18.85–24.29) | 41.88 (37.16–48.79) | 13.58 | 0.004  |
| Litsea viridis                        | n.t.         | n.t.         | —   | —      |
| Machilus balansae                     | n.t.         | n.t.         | —   | —      |
| Machilus grandifolia                  | 20.23 (18.61–21.93) | 29.29 (26.85–33.10) | 0.001037 | 1.000  |
| Neolitsea ellipsoidea                 | 6.587 (1.478–9.219) | 14.00 (10.88–17.71) | 0.000224 | 1.000  |
| Phoebe angustifolia                   | 24.29 (22.36–26.76) | 35.22 (31.70–41.19) | 0.1421 | 0.931  |
| *Aedes albopictus*                    |              |              |     |        |
| Beilschmiedia erythrophloia           | n.t.         | n.t.         | —   | —      |
| Beilschmiedia robusta                 | n.t.         | n.t.         | —   | —      |
| Beilschmiedia yunnanensis             | n.t.         | n.t.         | —   | —      |
| Cryptocarya concinna (Nam Dong)       | 34.21 (31.81–37.04) | 43.97 (40.67–48.59) | 4.651 | 0.098  |
| Cryptocarya concinna (Pu Hoat)        | n.t.         | n.t.         | —   | —      |
| Cryptocarya impressa                   | n.t.         | n.t.         | —   | —      |
| Cryptocarya infectoria                | 61.34 (56.76–67.52) | 81.29 (73.86–93.08) | 3.000 | 0.223  |
| Litsea viridis                        | n.t.         | n.t.         | —   | —      |
| Machilus balansae                     | n.t.         | n.t.         | —   | —      |
| Machilus grandifolia                  | 16.48 (14.82–18.02) | 25.00 (22.90–28.16) | 1.86 × 10⁻⁵ | 1.000  |
| Neolitsea ellipsoidea                 | n.t.         | n.t.         | —   | —      |
| Phoebe angustifolia                   | 40.18 (36.12–44.88) | 69.56 (62.08–80.81) | 31.94 | 0.000  |
Table 5. Cont.

| Lauraceae species | LC$_{50}$ | LC$_{90}$ | $\chi^2$ | $p$          |
|------------------|----------|----------|----------|--------------|
|                  |          |          |          |              |
| Cu. quinquefasciatus |          |          |          |              |
| Beilschmiedia erythrophyloa | n.t.     | n.t.     | —        | —            |
| Beilschmiedia robusta | n.t.     | n.t.     | —        | —            |
| Beilschmiedia yunnanensis | n.t.     | n.t.     | —        | —            |
| Cryptocarya concinna (Nam Dong) | 56.28(52.14–62.30) | 75.33(67.95–88.18) | 0.5537 | 0.758          |
| Cryptocarya concinna (Pu Hoat) | n.t.     | n.t.     | —        | —            |
| Cryptocarya impressa | n.t.     | n.t.     | —        | —            |
| Cryptocarya infectoria | 10.82(6.86–14.27) | 53.37(41.49–79.45) | 18.66 | 0.000          |
| Litsea viridis | n.t.     | n.t.     | —        | —            |
| Machilus balansae | n.t.     | n.t.     | —        | —            |
| Machilus grandifolia | 13.59(11.51–15.24) | 22.48(20.34–25.94) | 6.1 x 10$^{-6}$ | 1.000          |
| Neolitsea ellipsoidea | 7.465(3.904–9.956) | 19.84(16.52–25.64) | 0.1427 | 0.931          |
| Phoebe angustifolia | 20.70(19.36–21.96) | 26.60(25.10–28.63) | 0.000 | 1.000          |

n.t. = not tested due to insufficient essential oil.

The major component of *N. ellipsoidea* leaf essential oil, (E)-β-ocimene (87.6%), is not likely responsible for the observed larvicidal activity. The (E)-β-ocimene-rich (94.8%) essential oil of *Porophyllum ruderale* showed an LC$_{50}$ of 173.7 µg/mL against *Ae. aegypti* [44]. Likewise, the essential oil of *Syzygium jambolana*, with (Z)-β-ocimene (27.2%) and (E)-β-ocimene (12.2%), was inactive against *Ae. aegypti* (LC$_{50}$ = 433 µg/mL) [45]. The excellent larvicidal activity of *N. ellipsoidea* essential oil can likely be attributed to synergistic effects involving minor components.

The leaf essential oil of *C. infectoria* was rich in the germacrene sesquiterpenes germacrene D (55.5%) and bicyclogermacrene (11.4%), and these compounds may be responsible for the larvicidal activity. Germacrene D has demonstrated notable larvicidal activity against *Ae. aegypti* and *Cx. quinquefasciatus* (LC$_{50}$ = 18.8 and 21.3 µg/mL, respectively) [46], and bicyclogermacrene was larvicidal against *Ae. albopictus* and *Cx. tritaeniorhynchus* (LC$_{50}$ = 11.1 and 12.5 µg/mL, respectively) [47].

Table 6. Forty-eight-hour larvicidal activities of Lauraceae leaf essential oils from Vietnam.

| Lauraceae species | LC$_{50}$ | LC$_{90}$ | $\chi^2$ | $p$          |
|------------------|----------|----------|----------|--------------|
|                  |          |          |          |              |
| *Aedes aegypti*  |          |          |          |              |
| Beilschmiedia erythrophyloa | n.t.     | n.t.     | —        | —            |
| Beilschmiedia robusta | 22.00(19.81–24.45) | 35.64(31.82–41.93) | 0.6316 | 0.427          |
| Beilschmiedia yunnanensis | n.t.     | n.t.     | —        | —            |
| Cryptocarya concinna (Nam Dong) | 32.03(29.72–34.84) | 42.58(39.12–47.64) | 0.1879 | 0.910          |
| Cryptocarya concinna (Pu Hoat) | 16.22(12.81–18.90) | 33.46(29.37–40.63) | 1.028 | 0.598          |
| Cryptocarya impressa | n.t.     | n.t.     | —        | —            |
| Cryptocarya infectoria | 18.94(16.39–21.65) | 39.12(34.54–45.97) | 13.16 | 0.004          |
| Litsea viridis | n.t.     | n.t.     | —        | —            |
| Machilus balansae | n.t.     | n.t.     | —        | —            |
| Machilus grandifolia | 16.17(14.61–17.64) | 24.03(22.07–26.93) | 1.4 x 10$^{-6}$ | 1.000          |
| Neolitsea ellipsoidea | 4.038(0.004–7.585) | 11.12(2.12–14.74) | 0.004978 | 0.998          |
| Phoebe angustifolia | 22.46(20.59–24.69) | 33.44(30.10–39.07) | 0.06258 | 0.969          |

| *Aedes albopictus* |          |          |          |              |
|                   |          |          |          |              |
| Beilschmiedia erythrophyloa | n.t.     | n.t.     | —        | —            |
| Beilschmiedia robusta | n.t.     | n.t.     | —        | —            |
| Beilschmiedia yunnanensis | n.t.     | n.t.     | —        | —            |
| Cryptocarya concinna (Nam Dong) | 30.19(27.92–33.28) | 40.26(36.49–46.42) | 1.922 | 0.383          |
| Cryptocarya concinna (Pu Hoat) | n.t.     | n.t.     | —        | —            |
| Cryptocarya impressa | n.t.     | n.t.     | —        | —            |
| Cryptocarya infectoria | 58.80(54.40–64.96) | 78.50(71.00–90.93) | 1.282 | 0.527          |
| Litsea viridis | n.t.     | n.t.     | —        | —            |
| Machilus balansae | n.t.     | n.t.     | —        | —            |
| Machilus grandifolia | 15.45(13.62–17.07) | 24.47(22.28–27.88) | 3.69 x 10$^{-5}$ | 1.000          |
| Neolitsea ellipsoidea | n.t.     | n.t.     | —        | —            |
| Phoebe angustifolia | 35.28(31.29–39.67) | 64.97(57.71–76.08) | 23.97 | 0.000          |
Table 6. Cont.

| Lauraceae species                        | LC50 (µg/mL) | LC90 (µg/mL) | χ² | p   |
|-----------------------------------------|-------------|-------------|----|-----|
| *Beilschmiedia erythrophloia*           | n.t.        | n.t.        | —  | —   |
| *Beilschmiedia robusta*                 | n.t.        | n.t.        | —  | —   |
| *Beilschmiedia yunnanensis*             | n.t.        | n.t.        | —  | —   |
| Cryptocarya concinna (Nam Dong)         | 41.89 (37.88–46.65) | 69.84 (62.41–80.77) | 5.550 | 0.062 |
| *Cryptocarya impressa*                  | n.t.        | n.t.        | —  | —   |
| Cryptocarya infectoria                   | 4.02 (0.000–2.947) | 11.39 (0.04–21.64) | 6.397 | 0.041 |
| Litsea viridis                          | n.t.        | n.t.        | —  | —   |
| Machilus balansae                       | n.t.        | n.t.        | —  | —   |
| Neolitsea ellipsoidea                   | 4.650 (0.061–7.988) | 11.89 (4.63–15.36) | 0.002409 | 0.999 |
| *Phoebe angustifolia*                    | 12.21 (8.66–14.46) | 24.28 (21.55–29.24) | 0.002467 | 0.999 |

n.t. = not tested due to insufficient essential oil.

The marginal larvicidal activity of *C. concinna* from Nam Dong is consistent with the marginal activities observed for the major components. (E)-Caryophyllene, caryophyllene oxide, and α-pinene have shown modest mosquito larvicidal activities [48]. β-Pinene, however, has been shown to be more active than α-pinene: (−)-β-pinene (LC50 = 65 µg/mL against *Cx. quinquefasciatus*) [49], (LC50 = 15.4 µg/mL against *Ae. aegypti*) [50]; (+)-β-pinene (LC50 = 22.4 µg/mL against *Ae. aegypti*) [49]. Spathulenol-rich essential oils have also shown only marginal larvicidal activities. The stem essential oil of *Tephrosia toxicaria* (42.3% spathulenol) had an LC50 of 63.1 µg/mL against *Ae. aegypti* [51], while *Guarea sylvatica* essential oil from branches (14.3% spathulenol) showed LC50 against *Ae. aegypti* of 274 µg/mL [52].

2.3. Antimicrobial Activity

Several of the leaf essential oils of the Lauraceae were screened for antimicrobial activity (Table 7). All of the essential oils tested showed good antibacterial activities against the Gram-positive organisms. Both *L. viridis* and *N. ellipsoidea* leaf essential oils demonstrated particularly notable activities against *E. faecalis* and *B. cereus* with minimum inhibitory concentration (MIC) values of 16 µg/mL. The leaf essential oil of *C. impressa* also showed excellent antifungal activity against *C. albicans* with an MIC of 16 µg/mL.

The major component of *L. viridis* leaf oil, bicyclogermacrene, has shown antibacterial activity against *B. cereus* [53]. Likewise, β-pinene was shown to be active against *E. faecalis* [54] as well as several other Gram-positive organisms [55]. Similarly, α-pinene has activity against several Gram-positive bacteria [55,56]. Decanal has also exhibited antibacterial activity [57,58]. Thus, the major components of *L. viridis* leaf essential oil, bicyclogermacrene, decanal, α-pinene, and β-pinene, can account for the observed antibacterial activity.

(E)-β-Ocimene dominated the leaf essential oil of *N. ellipsoidea*, but this compound has demonstrated relatively marginal antibacterial activity [55]. Synergistic interactions of (E)-β-ocimene with minor essential oil components may play a role in the antibacterial activity of *N. ellipsoidea* leaf oil.

The components responsible for the antifungal activity of *C. impressa* leaf essential oil are not obvious. Neither (E)-caryophyllene nor α-humulene have shown strong anti- *Candida albicans* activity [54,56]. The antifungal activity of bicyclogermacrene itself has apparently not been determined. However, essential oils rich in both bicyclogermacrene and (E)-caryophyllene do not exhibit notable activity against *Candida* spp. [59,60]. Decanal, however, has shown activity against *C. albicans* with an MIC of 125 µg/mL [61].
Table 7. Antimicrobial activities of leaf essential oils of Lauraceae from Vietnam.

| Sample                          | Gram (+) | Gram (−) | Yeast | MIC (µg/mL) | IC₅₀ (µg/mL) |
|---------------------------------|----------|----------|-------|-------------|-------------|
|                                 | Enterococcus faecalis ATCC 299212 | Staphylococcus aureus ATCC 25923 | Bacillus cereus ATCC 14579 | Escherichia coli ATCC 25922 | Pseudomonas aeruginosa ATCC 27853 | Salmonella enterica ATCC 13076 | Candida albicans ATCC 10231 |
| Beilschmiedia erythrophloia     | 32       | 64       | n.a.  | 64          | n.a.        | n.a.       | n.a.      | 128        |
| Beilschmiedia robusta          | 64       | 64       | n.a.  | 64          | n.a.        | n.a.       | n.a.      | n.a.       |
| Beilschmiedia yunnanensis      | 64       | 64       | n.a.  | 64          | n.a.        | n.a.       | n.a.      | 256        |
| Cryptocarya concinna (Pu Hoat)  | 32       | 128      | 64    | n.a.        | 128         | 256        | 64        |
| Cryptocarya impressa            | 64       | 64       | 128   | 64          | n.a.        | n.a.       | n.a.      | 16         |
| Cryptocarya infectoria          | 128      | 64       | 128   | 64          | n.a.        | 64         | 128       | n.a.       |
| Litsea viridis                  | 16       | 64       | 16    | n.a.        | n.a.        | n.a.       | n.a.      | 128        |
| Machilus balansae               | 64       | 128      | 128   | n.a.        | n.a.        | n.a.       | n.a.      | n.a.       |
| Neolitsea ellipsoidea           | 16       | 32       | 16    | 128         | n.a.        | n.a.       | n.a.      | 128        |
| Streptomycin                    | 256      | 256      | 128   | 32          | 256         | 128        | n.t.      | 8          |
| Nistatin                        | n.t.     | n.t.     | n.t.  | n.t.        | n.t.        | n.t.       | n.t.      | 32         |
| Cyclohexamide                   | n.t.     | n.t.     | n.t.  | n.t.        | n.t.        | n.t.       | n.t.      | n.a.       |
| Beilschmiedia erythrophloia     | 10.34    | 20.34    | 34.78 | n.a.        | n.a.        | n.a.       | n.a.      | 56.78      |
| Beilschmiedia robusta          | 20.76    | 18.67    | n.a.  | 17.88       | n.a.        | n.a.       | n.a.      | n.a.       |
| Beilschmiedia yunnanensis      | 17.99    | 20.34    | 24.67 | n.a.        | n.a.        | n.a.       | n.a.      | 100.34     |
| Cryptocarya concinna (Pu Hoat)  | 8.99     | 40.67    | 18.99 | n.a.        | 48.98       | 145.34     | 25.67     |
| Cryptocarya impressa            | 20.34    | 28.77    | 47.67 | 18.78       | n.a.        | n.a.       | n.a.      | 5.89       |
| Cryptocarya infectoria          | 65.33    | 32.67    | 63.56 | n.a.        | 33.22       | 65.66      | 32.22     |
| Litsea viridis                  | 2.45     | 18.99    | 7.67  | n.a.        | n.a.        | n.a.       | n.a.      | 56.78      |
| Machilus balansae               | 18.78    | 50.35    | 45.77 | n.a.        | n.a.        | n.a.       | n.a.      | n.a.       |
| Neolitsea ellipsoidea           | 3.99     | 7.98     | 5.67  | 57.78       | n.a.        | n.a.       | n.a.      | 56.67      |

n.a. = not active; n.t. = not tested.
3. Materials and Methods

3.1. Plant Collection

Leaves were collected from wild-growing trees in north-central Vietnam. Plants were identified by Do Ngoc Dai and voucher specimens (Table 1) have been deposited in the plant specimen room, Faculty Agriculture, Forestry and Fishery, Nghe An, College of Economics. In each case, the fresh leaves were chopped and 2.0 kg was subjected to hydrodistillation using a Clevenger-type apparatus.

3.2. Analysis of the Oils

Gas chromatographic (GC) analysis was performed on an Agilent Technologies HP 7890A Plus Gas chromatograph equipped with a FID and fitted with HP-5ms column (30 m × 0.25 mm, film thickness 0.25 µm, Agilent Technologies, Santa Clara, CA, USA). The analytical conditions were: carrier gas H₂ (1 mL/min), injector temperature (PTV: programmable temperature vaporization) 250 °C, detector temperature 260 °C, column temperature programmed from 60 °C (2 min hold) to 220 °C (10 min hold) at 4 °C/min. Samples were injected using a split mode with a split ratio of 10:1. The volume injected was 1.0 µL. Inlet pressure was 6.1 kPa.

An Agilent Technologies (Santa Clara, CA, USA) HP 7890A Plus Chromatograph fitted with a fused silica capillary HP-5ms column (30 m × 0.25 mm, film thickness 0.25 µm) and interfaced with a mass spectrometer HP 5973 MSD was used for the GC/MS analysis, under the same conditions as those used for GC analysis. The conditions were the same as described above with He (1 mL/min) as carrier gas. The MS conditions were as follows: ionization voltage 70 eV; emission current 40 mA; acquisitions scan mass range of 35–350 amu at a sampling rate of 1.0 scan/s. Compound identification was carried out by comparison of the MS fragmentation patterns and calculated retention indices with those available in the databases [35–37] and, when available, with standard substances.

3.3. Mosquito Larvicidal Assays

Larvicidal activities against *Aedes aegypti*, *Aedes albopictus*, and *Culex quinquefasciatus* were carried out as previously described [62]; LC₅₀ values, LC₉₀ values, and 95% confidence limits were determined by log-probit analysis using Minitab® 19 (Minitab, LLC, State College, PA, USA).

3.4. Antimicrobial Assays

The bacterial growth inhibition of the essential oils was evaluated using three strains of Gram-positive test bacteria, *Enterococcus faecalis* (ATCC299212), *Staphylococcus aureus* (ATCC25923), *Bacillus cereus* (ATCC14579), three strains of Gram-negative test bacteria, *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC27853), *Salmonella enterica* (ATCC13076) and one strain of yeast, *Candida albicans* (ATCC 10231). Minimum inhibitory concentration (MIC) and median inhibitory concentration (IC₅₀) values were measured by the microdilution broth susceptibility assay as previously described [62].

4. Conclusions

Of the eleven species of Lauraceae examined in this work, the leaf essential oil of *Neolitsea ellipsoidea*, dominated by (E)-β-ocimene, showed excellent larvicidal activity against *Aedes aegypti* and antibacterial activity against *Enterococcus faecalis* and *Bacillus cereus*; Cryptocarya infectoria leaf essential oil, rich in germacrene D and bicyclogermacrene, showed excellent larvicidal activity on *Culex quinquefasciatus* and antican didal activity against *Candida albicans*. The leaf essential oil of *Litsea viridis*, which was rich in bicyclogermacrene, also showed good antibacterial properties. The biological properties of these Lauraceae essential oils suggest that they may serve as potential “green” alternatives, as also described for Lamiaceae family plants [63], for use as insect control or antimicrobial agents.
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