Niche Differentiation of Lauraceae Species in Structuring a Tropical Lower Montane Forest in Northern Thailand

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Highland forests in Thailand

(Gardner et al. 2000)

Study site

Hill evergreen

Headwater catchment

Moist hill evergreen

Vegetation types

- moist hill evergreen
- evergreen/deciduous
- deciduous/bamboo
- dry dipterocarp

- evergreen deciduous
- moist evergreen

- pine/dry evergreen

WET

MOISTURE

DRY

Moist evergreen

Secondary growth

Hill evergreen

Gardner et al. 2000

Study site
Objectives of the study

• To clarify the habitat niches of 20 Lauraceae species in a tropical montane forest in Thailand

• To clarify the regeneration niches of five sympatric Lauraceae species
Study site
15-ha Forest Dynamics Plot in Doi Inthanon National Park, northern Thailand
15-ha Plot established in a lower montane forest at 1700 m altitude
Mean annual rainfall: 2279 mm
Mean maximum temperature: 18.6°C
Mean minimum temperature: 7.2°C
Doi Inthanon Forest Dynamics Plot (15-ha)
Contour lines are drawn at every 20 m interval.
## Importance of Lauraceae in the 15-ha plot

<table>
<thead>
<tr>
<th>Rank</th>
<th>Family</th>
<th>Basal Area (m²)</th>
<th>% BA</th>
<th>Family</th>
<th>Trees</th>
<th>% Trees</th>
<th>Family</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fagaceae</td>
<td>122.7</td>
<td>20.1</td>
<td>Lauraceae</td>
<td>10797</td>
<td>14.7</td>
<td>Lauraceae</td>
<td>25</td>
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<td>2</td>
<td>Lauraceae</td>
<td>92.2</td>
<td>15.1</td>
<td>Fagaceae</td>
<td>9683</td>
<td>13.1</td>
<td>Rubiaceae</td>
<td>13</td>
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<td>3</td>
<td>Cornaceae</td>
<td>87.4</td>
<td>14.3</td>
<td>Euphorbiaceae</td>
<td>8785</td>
<td>11.9</td>
<td>Myrsinaceae</td>
<td>11</td>
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<td>4</td>
<td>Euphorbiaceae</td>
<td>51.3</td>
<td>8.4</td>
<td>Rubiaceae</td>
<td>7340</td>
<td>10.0</td>
<td>Fagaceae</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Magnoliaceae</td>
<td>35.8</td>
<td>5.9</td>
<td>Guttiferae</td>
<td>5995</td>
<td>8.1</td>
<td>Euphorbiaceae</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Guttiferae</td>
<td>32.4</td>
<td>5.3</td>
<td>Myrtaceae</td>
<td>3689</td>
<td>5.0</td>
<td>Rosaceae</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Myrtaceae</td>
<td>25.7</td>
<td>4.2</td>
<td>Theaceae</td>
<td>3428</td>
<td>4.7</td>
<td>Theaceae</td>
<td>5</td>
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<tr>
<td>8</td>
<td>Rubiaceae</td>
<td>17.0</td>
<td>2.8</td>
<td>Meliaceae</td>
<td>3043</td>
<td>4.1</td>
<td>Moraceae</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Oleaceae</td>
<td>11.5</td>
<td>1.9</td>
<td>Myrsinaceae</td>
<td>2729</td>
<td>3.7</td>
<td>Meliaceae</td>
<td>4</td>
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<tr>
<td>10</td>
<td>Aceraceae</td>
<td>11.4</td>
<td>1.9</td>
<td>Rutaceae</td>
<td>2681</td>
<td>3.6</td>
<td>Rutaceae</td>
<td>4</td>
</tr>
</tbody>
</table>
Cryptocarya densiflora

Litsea beusekomii

Lindera metcalfiana
Species list in 7.5-ha area used for this study

<table>
<thead>
<tr>
<th>Species</th>
<th>Tree density (/ha)</th>
<th>Basal area (m²/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinodaphne sp.</td>
<td>10.3</td>
<td>0.07</td>
</tr>
<tr>
<td>Beilschmiedia glauca</td>
<td>26.4</td>
<td>0.07</td>
</tr>
<tr>
<td>Cinnamomum bejolghota</td>
<td>22.8</td>
<td>0.22</td>
</tr>
<tr>
<td>Cinnamomum soegengii</td>
<td>19.3</td>
<td>0.59</td>
</tr>
<tr>
<td>Cinnamomum sp.</td>
<td>0.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cryptocarya calcicola</td>
<td>79.3</td>
<td>0.73</td>
</tr>
<tr>
<td>Cryptocarya densiflora</td>
<td>111.9</td>
<td>2.16</td>
</tr>
<tr>
<td>Lindera metcalfiana</td>
<td>128.0</td>
<td>0.74</td>
</tr>
<tr>
<td>Litsea beusekomii</td>
<td>132.1</td>
<td>0.16</td>
</tr>
<tr>
<td>Litsea cubeba</td>
<td>2.0</td>
<td>0.01</td>
</tr>
<tr>
<td>Litsea lancifolia</td>
<td>67.7</td>
<td>0.26</td>
</tr>
<tr>
<td>Litsea membranifolia</td>
<td>2.3</td>
<td>0.02</td>
</tr>
<tr>
<td>Litsea pedunculata</td>
<td>23.6</td>
<td>0.56</td>
</tr>
<tr>
<td>Litsea subcorriacea</td>
<td>31.2</td>
<td>0.55</td>
</tr>
<tr>
<td>Litsea yunnanensis</td>
<td>88.0</td>
<td>0.69</td>
</tr>
<tr>
<td>Neolitsea zeylanica</td>
<td>13.5</td>
<td>0.10</td>
</tr>
<tr>
<td>Neolitsea sp.</td>
<td>0.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Persea duthiei</td>
<td>0.8</td>
<td>0.08</td>
</tr>
<tr>
<td>Phoebe sp.</td>
<td>19.9</td>
<td>0.38</td>
</tr>
<tr>
<td>Unidentified sp.</td>
<td>5.7</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Total of Lauraceae</strong></td>
<td><strong>785.6</strong></td>
<td><strong>7.63</strong></td>
</tr>
<tr>
<td><strong>Total of all species</strong></td>
<td><strong>4173.7</strong></td>
<td><strong>42.44</strong></td>
</tr>
</tbody>
</table>

9 Genera, 20 spp.
1. Habitat Niches

2. Regeneration Niches
   a) Seedfall and germination
   b) Buried seed dynamics
   c) Response of seedlings to light

3. Final conclusion
Spatial distribution pattern of 17 Lauraceae species in the study area (7.5 ha)
Dendrogram of 17 Lauraceae species based on the spatial association (Iwao’s index) between species.
Two groups of Lauraceae species based on the spatial associations.

Group A  Valley species
- Litsea subcorriacea
- Cryptocarya densiflora
- Cryptocarya cf. calcicola
- Litsea cf. membranifolia
- Litsea beusekomii
- Litsea yunnanensis
- Litsea lancifolia
- Cinnamomum soegengii
- Unidentified sp
- Beilschmiedia cf. glauca

Group B  Ridge species
- Phoebe sp.
- Litsea cubeba
- Linderia metcalffiana
- Litsea pedunculata
- Neolitsea zyylanica
- Actinodaphne sp.
- Cinnamomum bejolghota

N
Step 1: Discriminant analysis

A discriminant model predicts the presence/absence of focal tree species.

Fitness of the model = canonical coefficient of correlation, $r$

Significance test = $\chi^2$ test

From the elevation data of four corners of a 20 m x 20 m square, the topographical variables are calculable.
Step 2 : Torus-randomization

Actual map
*Lindera metcalfiana*

A randomized map
X axis 100 m, Y axis 80 m

No. of iterations = 100 •
Determination of discriminant models and \( r \) values for respective iterations
Step 3: Statistical test

Frequency distribution of “$r$” from 100 randomized maps

- **Lindera metcalfiana**
  - $N=100$
  - Observed value $p<0.01$

- **Cryptocarya densiflora**
  - $N=100$
  - Observed value $p<0.31$ NS

Canonical coefficient of correlation, $r$
Results of the discriminant analysis using a four-variable model applied to the presence-absence data of Lauraceae species

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of squares present</th>
<th>Canonical correlation</th>
<th>Chi-square test of Wilks' lambda</th>
<th>Randomization test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litsea subcorriacea</td>
<td>83</td>
<td>0.301</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Cryptocarya densiflora</td>
<td>122</td>
<td>0.197</td>
<td>0.24</td>
<td>0.39</td>
</tr>
<tr>
<td>Cryptocarya calcicola</td>
<td>118</td>
<td>0.461</td>
<td>&lt;0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Litsea cf. membranifolia</td>
<td>11</td>
<td>0.174</td>
<td>0.37</td>
<td>0.45</td>
</tr>
<tr>
<td>Litsea beusekom ii</td>
<td>101</td>
<td>0.612</td>
<td>&lt;0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Litsea yunnanensis</td>
<td>115</td>
<td>0.490</td>
<td>&lt;0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Litsea lancifolia</td>
<td>68</td>
<td>0.762</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
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<tr>
<td>Cinnamomum soegengii</td>
<td>57</td>
<td>0.487</td>
<td>&lt;0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Unidentified sp.</td>
<td>24</td>
<td>0.314</td>
<td>0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Beilschmiedia glauca</td>
<td>39</td>
<td>0.535</td>
<td>&lt;0.01</td>
<td>0.04</td>
</tr>
<tr>
<td>Phoebe sp.</td>
<td>37</td>
<td>0.565</td>
<td>&lt;0.01</td>
<td>0.08</td>
</tr>
<tr>
<td>Litsea cubeba</td>
<td>4</td>
<td>0.270</td>
<td>0.03</td>
<td>0.21</td>
</tr>
<tr>
<td>Lindera metcalfiana</td>
<td>67</td>
<td>0.730</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Litsea pedunculata</td>
<td>58</td>
<td>0.455</td>
<td>&lt;0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Neolitsea zeylanica</td>
<td>33</td>
<td>0.364</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Actinodaphne sp.</td>
<td>42</td>
<td>0.264</td>
<td>0.04</td>
<td>0.17</td>
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<tr>
<td>Cinnamomum bejolghota</td>
<td>61</td>
<td>0.266</td>
<td>0.04</td>
<td>0.33</td>
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</tbody>
</table>
Results of the stepwise variable selection in the discriminant analysis for species with significant topography dependence

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage of correct classification</th>
<th>Relative elevation</th>
<th>Slope inclination</th>
<th>Slope direction</th>
<th>Slope convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litsea subcorriacea</td>
<td>58.7</td>
<td>1.408</td>
<td>-</td>
<td>-</td>
<td>-1.075</td>
</tr>
<tr>
<td>Cryptocarya calcicola</td>
<td>71.3</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Litsea beusekomii</td>
<td>81.1</td>
<td>0.509</td>
<td>-</td>
<td>0.355</td>
<td>0.558</td>
</tr>
<tr>
<td>Litsea yunnanensis</td>
<td>74.1</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Litsea lancifolia</td>
<td>86.0</td>
<td>0.713</td>
<td>0.347</td>
<td>-</td>
<td>0.499</td>
</tr>
<tr>
<td>Cinnamomum soegengii</td>
<td>72.7</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Unidentified sp.</td>
<td>62.2</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beilschmiedia glauca</td>
<td>73.4</td>
<td>1.202</td>
<td>-0.501</td>
<td>-</td>
<td>-0.558</td>
</tr>
<tr>
<td>Lindera metcalfiana</td>
<td>86.7</td>
<td>0.691</td>
<td>-</td>
<td>-</td>
<td>0.476</td>
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<tr>
<td>Litsea pedunculata</td>
<td>70.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.000</td>
</tr>
<tr>
<td>Neolitsea zeylanica</td>
<td>63.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Habitat Niches

- 11 Species showed the significant dependence on topography.
- 8 Species were valley specialist, 3 species were ridge specialist and 6 were generalist.
1. Habitat Niches

2. Regeneration Niches
   a) Seedfall and germination
   b) Buried seed dynamics
   c) Response of seedlings to light

3. Conclusion
### Cinnamomum soegengii
- Seed dry weight: 1.760 g

### Lindera metcalfiana
- Seed dry weight: 0.046 g

### Litsea cubeba
- Seed dry weight: 0.027 g

### Cryptocarya densiflora
- Seed dry weight: 1.085 g
Cumulative number of seeds per tree

**Lindera metcalfiana**

- Dispersal

**Cinnamomum soegengii**

- Dispersal
- Germination

**Litsea cubeba**

- Rainy season

**Cryptocarya densiflora**

Rainy season
Days from seed fall to germination

**Cinnamomum soegengii**
- N = 786

**Cryptocarya densiflora**
- N = 486
Seed mortality

- Cryptocarya densiflora
- Cinnamomum soegengii

Mortality before germination

Mortality factor

Herbivore
Fungi
Unidentified
Seedling mortality

- Cryptocarya densiflora
- Cinnamomum soegengii

Mortality after germination

Mortality factor

- Herbivore
- Fungi
- Wilting
- Unidentified
Conclusions 2

Seedfall and germination *in situ*

- Possibility of seed dormancy in *Litsea cubeba* and *Lindera metcalfiana*

- Earlier onset of germination in *Cinnamomum soegengii* with hypothetical chemical defense against herbivores

- Later onset of germination in *Cryptocarya densiflora* possibly without chemical defense against herbivores
1. Habitat Niches

2. Regeneration Niches
   a) Seedfall and germination
   b) Buried seed dynamics
   c) Response of seedlings to light

3. Final conclusion
Survival of seeds buried in a closed forest
Results of the germination test in an open site

Lindera metcalfiana

Litsea cubeba

Cumulative germination (per sown seed)

Days after sowing

0 days burial

30 days burial

438 days burial

753 days burial

122 days burial

723 days burial

408 days burial

0, 30, 122 days burial
Difference in germination rates among the seeds with various burial periods

- *Lindera metcalfiana*
- *Litsea cubeba*
Buried seed dynamics

• Successful seed bank construction in *Lindera metcalfiana* and *Litsea cubeba*

• Initial deep dormancy in *Litsea cubeba*
1. Habitat Niches

2. Regeneration Niches
   a) Seedfall and germination
   b) Buried seed dynamics
   c) Response of seedlings to light

3. Final conclusion
Shade frame experiment

Frame size: 1 m(L) × 2 m(W) × 1.2 m(H)

5 Treatments: 3.4%, 10%, 31%, 51%, 100% relative light intensity

3 Species: *Cinnamomum bejolghota*, *Cinnamomum soegengii*, *Cryptocarya densiflola*

3 Replicates for each treatment
Cinnamomum soegengii

Cryptocarya densiflora

Cinnamomum bejolghota
Relationships between relative light intensity and mean seedling weight

- **Cinnamomum soegengii**
  - $f_{opt} = 11.4\%$
  - Index of specialization (IS) = 25

- **Cinnamomum bejolghota**
  - $f_{opt} = 22.6\%$
  - Index of specialization (IS) = 31

- **Cryptocarya densiflora**
  - $f_{opt} = 16.9\%$
  - IS = 24

- **Graph:**
  - X-axis: Relative light intensity (%)
  - Y-axis: Mean dry weight (g)
Conclusions 4

Response of seedlings to light

• Ubiquity of light as an optimum factor in seedling growth

• Specialization of *Cinnamomum bejolghota* in higher light intensity

• Moderate light requirement of *Cinnamomum soegengii* and *Cryptocarya densiflora*
1. Habitat Niches

2. Regeneration Niches
   a) Seedfall and germination
   b) Buried seed dynamics
   c) Response of seedlings to light

3. Final conclusion
Niche differentiation in examined Lauraceae species

Habitat preference

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Light requirement</td>
<td>Low (climax)</td>
<td>High (pioneer)</td>
<td>Low (climax)</td>
</tr>
</tbody>
</table>

- **Lindera metcalfiana**
- **Litsea cubeba**
- **Cinnamomum bejolghota**
- **Cryptocarya densiflora**
- **None?**
- **Cinnamomum soegengii**