Geographic Distributions and Ecology of Ornamental
Curcuma (Zingiberaceae) in Northeastern Thailand

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Abstract: The genus Curcuma is a very important economic plant. Members of this genus were used as food,
medicine and ornamental plants. The objectives of this study were to examine the geographic distributions and
ecological conditions in the natural habitats of Curcuma in Northeastern Thailand. Species diversity was
examined using the line transect method. Ecological conditions of the species were examined using a sampling
plot of 20×20 m. A total of five species were found including Curcuma angustifolia Roxb., C. alismatifolia
Gagnep., C. gracilima Gagnep., C. parviflora Wall. and C. rhabdota. These species were in an altitudinal
range between 250 m and 831 m above sea level. Four species (C. angustifolia, C. alismatifolia, C. gracilima
and C. rhabdota) were distributed in open gaps in dry dipterocarp forest. One species, C. parviflora was found
in the contact zone between dry dipterocarp and bamboo (Gigantochloa sp.) forest. C. rhabdota was found
only in a habitat with high humidity and shading along the Thailand-Lao PDR border. Significant ecological
conditions of the natural habitats of these Curcuma species were identified. Altitude is the most important
factor when determining the geographic distributions of these Curcuma species in Northeastern Thailand.

Key words: Curcuma, ecology, zingiberaceae, Thailand, geographic distribution

INTRODUCTION

The genus Curcuma L. belongs to the family Zingiberaceae (Ridley, 1924). Members of this genus are
found in South and Southeast Asia. Some species are also found in China, Australia and the South Pacific
(Apavatjrut et al., 1999; Leong-Skommekova et al., 2008). The genus Curcuma is geographically wide spread in all
regions of Thailand, but it is mostly found in the North and Northeastern regions. The number of species of
Curcuma reported in Thailand varies between 50 and 100 species (Smith, 1981; Larsen et al., 1998; Sirirugsa, 1996).

Many species of Curcuma have been used as food, medicine and decorative plants (Schumann, 1904;
Leong-Skommekova et al., 2008). Some species have beautiful colors and compound spikes with prominent
bracts. The inflorescence has different colors, sizes and shapes. The general colors are yellow, orange, red, pink
and white. Curcuma species grown for trading have been gathered and developed from wild species and cross
breed to respond to the market that demands different plants, beautiful flowers and longer life. In addition to its
beauty, these plants also contains essential oils that are used as a traditional medicine to cure skin disease, rashes,
sores and sprains; it also reduces wound inflammation, eliminates gas in intestines and treats dyspepsia
(Purseglove, 1974; Heywood, 1985; Majeed et al., 1995; Apavatjrut et al., 1999; Mahadathanpuk et al., 2006). The
rhizome can be used as cloth dye, food dye, a food ingredient and as a spice to give a hot taste
(Bhowmik et al., 2009).

According to Thai export statistics, ornamental Curcuma (e.g. C. alismatifolia) was ranked seconded to
orchids (Del Pilar Paz et al., 2007). As a result, several species of Curcuma have been collected from their natural
habitat and then used for variety improvement (e.g., C. gracilima Gagnep., (C. thorelii synonym),
C. parviflora Wall., C. roscocana Wall. and C. harmandii Gagnep.). Due to the high demand for Curcuma spp. it is
important to consider the maintenance of the species in their natural habitats and for future research and
development use. The objective of this study was to determine the geographic distributions and ecological
conditions of the microhabitats of ornamental Curcuma.
species in Northeastern Thailand. The results of this study will be useful for conservation and selective breeding of these important plants.

**MATERIALS AND METHODS**

**Study area:** The study areas were selected in four National Parks (NP) in the Northeastern region of Thailand where *C. alismatifolia* and other ornamental *Curcuma* species are found, including, (1) Phu Phan NP, Sakon Nakhon Province, (2) Kaeng Tana NP, Ubon Ratchathani Province, (3) Sai Thong NP and (4) Pa Hin Ngam NP, Chaiyaphum Province (Fig. 1).

Phu Phan NP has a total area of 664.71 km². The topography of this site is composed of high mountains, sloping land with small steep mountains spreading in clusters. There are three types of forest: dry dipterocarp forest covered about 41.58% dry evergreen forest covered about 22.16% and mixed deciduous forest covered about 17.49% of the total area (Bunnag et al., 1999).

Kaeng Tana NP has a total area of 80 km². General topography is plateau and low mountains, while the Mun and Khong rivers passed through. The average elevation was 200 m above sea level. The forest types found in this area are dry evergreen forest covering approximately 83.5% and dry dipterocarp forest covering approximately 84% of the total area (BDP, 2004).

Sai Thong NP has a total area of 319 km². The topography is a mixture of high and low mountains that are at an altitudes from 300 m to 1,000 m above sea level. The forest types are classified into three categories i.e., dry evergreen forest, dry dipterocarp forest and mixed deciduous forest (BDP, 2004).

Pa Hin Ngam NP has a total area of 99.9 km². The topography includes a mountain range consisting of several mountains with altitudes ranging between 200 m and 800 m above sea level. The forest types are dry dipterocarp forest and mixed deciduous forest (Sudee, 1994).

**Sample collection and identification:** Samples were collected from four national parks in Northeastern Thailand (Table 1, Fig. 1) using line transect and sampling plot methods during June to October 2011. Species were identified using the keys and descriptions of *Curcuma* from Wu and Larsen (2000) and Maknok (2006). Geographic positions of the species were recorded using a GRAMIN GPS 60 model (Table 1). Environmental conditions at the sampling location were measured from a sampling plot (20*20 m²). Soil density (kg m⁻³) was measured by Bijkamp P.O. Agrisearch equipment box 6987 ZG and was pH measured by Soil pH Moisture Tester.

**Data analysis:** One-way analysis of variance (One-way ANOVA) was used to test the differentiation of the soil density, pH and altitude between species. Principal Components Analysis (PCA) was used to group the habitats of *Curcuma* species according to similarities in environmental conditions.

**RESULTS AND DISCUSSION**

**Species diversity and geographic distributions:** Five species (*C. angustifolia* Roxb., *C. alismatifolia* Gagnep., *C. gracilimina* Gagnep., *C. parviflora* Wall. and *C. rhabdota* (Siriruggsa and M. Newman, 2000)) of the ornamental *Curcuma* were found in the four...
Fig. 1: Approximate locations of the study areas in four national parks in Northeastern Thailand and (inset) map of Thailand showing the area of the Northeastern Region (shaded).

Fig. 2(a-h): Ornamental Curcuma species found in this study (a and b) *Curcuma alismatifolia* (c and d), *Curcuma parviflora* (e and f), *Curcuma gracillima* (g), *Curcuma angustifolia* (h), *Curcuma rhodota*.

National Parks in Northeastern Thailand (Table 2, Fig. 1-2). Four species were found in Sai Thong NP and Phu Phan NP, including *C. angustifolia*, *C. alismatifolia*, *C. gracillima* and *C. parviflora*. Three species...
Table 2: Ecological conditions in sampling plot (20×20 m) and list of species of Curcuma found in four national parks in Northeastern Thailand

<table>
<thead>
<tr>
<th>Study area</th>
<th>Plot No.</th>
<th>Species list</th>
<th>Altitude (m)</th>
<th>Soil pH</th>
<th>Soil density (kg m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KT</td>
<td>I</td>
<td>C. angustifolia</td>
<td>158</td>
<td>6.84</td>
<td>483.4</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>C. angustifolia</td>
<td>137</td>
<td>6.81</td>
<td>516.0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>C. gracillima</td>
<td>121</td>
<td>6.62</td>
<td>428.0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>C. rhodotata</td>
<td>792</td>
<td>6.80</td>
<td>420.0</td>
</tr>
<tr>
<td>PH</td>
<td>I</td>
<td>C. alismatofolia</td>
<td>814</td>
<td>6.63</td>
<td>456.0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>C. gracillima</td>
<td>801</td>
<td>6.74</td>
<td>452.0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>C. alismatofolia</td>
<td>804</td>
<td>6.78</td>
<td>443.5</td>
</tr>
<tr>
<td>ST</td>
<td>I</td>
<td>C. gracillima</td>
<td>821</td>
<td>6.74</td>
<td>455.0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>C. alismatofolia</td>
<td>831</td>
<td>6.75</td>
<td>418.0</td>
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<tr>
<td></td>
<td>III</td>
<td>C. gracillima</td>
<td>810</td>
<td>6.78</td>
<td>443.5</td>
</tr>
<tr>
<td>PP</td>
<td>I</td>
<td>C. alismatofolia</td>
<td>302</td>
<td>6.31</td>
<td>418.0</td>
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<tr>
<td></td>
<td>II</td>
<td>C. alismatofolia</td>
<td>290</td>
<td>6.28</td>
<td>424.0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>C. parviflora</td>
<td>289</td>
<td>6.45</td>
<td>480.0</td>
</tr>
</tbody>
</table>

Table 3: Statistical analysis of soil densities, pHs, and altitudes of five species of Curcuma

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Soil density (kg m⁻²)</th>
<th>pH</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td>Mean (±SE)</td>
</tr>
<tr>
<td>C. angustifolia</td>
<td>350.0</td>
<td>660.0</td>
<td>473±0.05</td>
</tr>
<tr>
<td>C. rhodotata</td>
<td>350.0</td>
<td>660.0</td>
<td>428±0.99</td>
</tr>
<tr>
<td>C. alismatofolia</td>
<td>350.0</td>
<td>660.0</td>
<td>429±3.76</td>
</tr>
<tr>
<td>C. gracillima</td>
<td>350.0</td>
<td>660.0</td>
<td>459±3.59</td>
</tr>
<tr>
<td>C. parviflora</td>
<td>450.0</td>
<td>460.0</td>
<td>460±2.00</td>
</tr>
</tbody>
</table>

Min. 350.0 Max. 660.0 Mean (±SE) 449±3.42 F-test 7.792 p-value <0.001

Means separation within columns by Duncan's multiple range test. Values in columns follow by the same letter are not statistically different.

(C. angustifolia, C. gracillima and C. rhodotata) were found in Kaeng Tana NP and three species (C. angustifolia, C. alismatofolia and C. gracillima) were found in Pa Hin Ngam NP (Table 2).

A previous study reported 13 species of Curcuma in Northeastern Thailand (Makon, 2006). The species that were not found in the present study included C. amada Roxb., C. harmandii Gagnep., C. petiolata Roxb., C. pierreana Gagnep., C. singularis Gagnep., C. sparganifolia Gagnep., C. stenochila Gagnep., and C. ubonratcathani (Makon, 2006). As different species flower at different times (Apavatjuth et al., 1999) and the flower is very important for species recognition in the Curcuma it could be possible that these species were not flowering during our sampling period, thus we were not able to collect them.

Two species were geographically widespread and covered almost all areas in Northeastern Thailand, they were C. alismatofolia and C. gracillima. C. alismatofolia was found in three national parks, namely Pa Hin Ngam NP, Sai Thong NP and Phu Phan NP. Curcuma gracillima was found in three national parks (Kaeng Tana NP, Pa Hin Ngam NP and Sai Thong NP). Our results are consistent with previous reports related to the geographic distributions of these species (Paisoolsantivatana et al., 2001, 2002; Saensouk, 2000; Saensouk and Chantaranonth, 2003). The geographically widespread nature of these species was consist with the wide range of ecological conditions that are suitable as habitats (Table 3) as species that can exploit a wide range of ecological niches will be distributed in a wider range of geographic areas.

Two species were geographically restricted to only one area. C. parviflora was found only in Phu Phan NP and C. rhodotata was found only in Kaeng Tana NP. First description of C. rhodotata reported that the samples were collected from the Lao PDR but the exact location was not identified (Sirirugs and Newman, 2000). Our results revealed that this species is also found in Thailand in Ubon Ratcathani Province, which is located along the Thailand-Lao PDR border.

Ecological conditions of the habitats: C. angustifolia was found in habitats with the highest soil density.
(473±9.05 kg m\(^{-2}\)) and pH (6.73±0.26). \textit{C. rhabadota} was found in the habitat with the lowest soil density (428±8.99 kg m\(^{-2}\)) and \textit{C. parviflora} found at the lowest pH (6.45±0.00) (Table 3). The \textit{Curcuma} species that were found at low altitude (<300 m above sea level) were \textit{C. angustifolia}, \textit{C. parviflora} and \textit{C. rhabadota}. \textit{C. angustifolia} was found in an altitude range between 121 and 290 m above sea level.

\textit{C. parviflora} and \textit{C. rhabadota} were geographically restricted to Phu Phun NP at an altitude of 289 m above sea level and Kaeng Tana NP at an altitude of 121 m above sea level, respectively. \textit{C. alismatifolia} and \textit{C. gracillima} were found at a wide range of altitudes from 137 to 831 m above sea level (Table 2).

Comparisons of the ecological conditions between habitats revealed significant differences among the \textit{Curcuma} species found in this study (Table 3). \textit{C. rhabadota} was found in a habitat with significantly lower soil density than the other species. \textit{C. parviflora} was found in a habitat with significantly lower pH than other species. \textit{C. alismatifolia} and \textit{C. gracillima} were found in habitats that were at significantly higher altitudes than \textit{C. angustifolia}, \textit{C. rhabadota} and \textit{C. parviflora}.

At the wider ecological scale (i.e., forest types) four species (\textit{C. angustifolia}, \textit{C. parviflora}, \textit{C. alismatifolia} and \textit{C. gracillima}) were found in dry dipterocarp forest and grass fields along the edges of the dry dipterocarp forest. One species, \textit{C. rhabadota} was found in a habitat composed of sedimentary clay that originated from the Mun River and had high moisture content. This specialized habitat requirement explains the narrow geographic distribution of this species.

Principal components analysis of the environmental conditions in the habitats revealed two Principal Components (PC) with eigenvalues higher than 1.0. The two PCS together accounted for 81.9% of the total variance. PC-1 accounted for 41.5% of the variation among species. Sampling plots with higher PC-1 scores have higher altitudes. PC-2 accounted for 39.4% of the variation in environmental variables. Sampling plots with higher PC-2 were high soil density and pH. Taken together, a plot of these two axes revealed three groups (group I, II and III) for the habitats of \textit{Curcuma} species (Fig. 3). The sampling site for \textit{C. parviflora} and almost all sampling sites for \textit{C. angustifolia} fell into group I which is characterized by high altitude with moderate soil density and pH. Most sampling sites for \textit{C. rhabadota} also fall in this group. Sampling sites for \textit{C. alismatifolia} and \textit{C. gracillima} belonged to group II which was characterized by high soil density and pH with moderate altitude. Some sampling site for \textit{C. alismatifolia} belonged to group III which was characterized by low altitude, soil density and pH. These results suggest that \textit{C. angustifolia}, \textit{C. parviflora} and \textit{C. rhabadota} are found mainly in higher altitude areas compare to \textit{C. alismatifolia} and \textit{C. gracillima} which are found mainly in lower altitude areas.
In conclusion, we found that *Curcuma* species in Northeastern Thailand largely overlap geographically but were also ecologically distinct. Our result indicates that altitude, pH and soil density are important ecological conditions habitats that determine the geographic distributions of *Curcuma* species.

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