International Journal of Advanced Science and Technology
Vol. 29, No. 5s, (2020), pp. 1967 - 1975

A Distribution of *Homalomena* Genus (Araceae) using the Ecological Niche Modeling in the State of Kelantan, Peninsular Malaysia

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Abstract

Five selected species of Homalomena genus from the Araceae family were used to test the ecological niche modeling technique in order to predict their potential habitat distribution in Kelantan. A total of 22 environmental variables were used in this study as parameter to model the potential habitat distribution. The results show the highest probability distribution of species within range of 60 – 100% probability noted in east, south and western part of Kelantan. Slope is indicated the main factor influencing the distributions of three species, namely, H. griffithii, H. truncata and H. wallichii. However, altitude and precipitation influencing the distribution of H. curvata and H. pontederifolia, respectively.

Keywords: *ecological niche modeling, Homalomena genus, Kelantan, Maxent, and species distribution.*

1. Introduction

Araceae is one of the largest families of monocotyledonous flowering plant, widely distributed in the tropical Asian region especially in South East Asia [36]. Most of species-rich and frequently found in humid lowland and montane forest [1]. A total of 121 genera with approximately 6000 species of Araceae was recorded worldwide, which 140 species from 28 genera were recorded in Peninsular Malaysia, and 25 species were endemic [37]-[38]. In Kelantan, 28 species from 11 genera were documented and *Homalomena* turned out to be the most diverse genus found in this area [37]. To date, there are eight species of *Homalomena* present in Kelantan including two new species found in Kuala Koh and Gunung Stong areas. These are *H. curvata* Engl., *H. griffithii* (Schott) Hook.f., *H. pontederifolia* Griff. ex Hook.f., *H. rostrata* Griff., *H. truncata* (Schott) Hook.f., *H. wallichii* Schott, *H. kualakohensis* Zulhazman, H., P.C. Boyce & Mashhor, M. and *H. stongensis* Zulhazman, H., P.C. Boyce & Mashhor, M. [20], [37]-[38].

The genus of *Homalomena* is understory herbaceous plant which usually found in lowland forest with ever moist to ever wet conditions [16]. According to [38], *Homalomena* mostly found in sloppy and ridges habitat and several species can survive in disturbed areas such as along road cuttings. Although lot of studies on Araceae were conducted in Peninsular Malaysia, only a few study focused on the distribution of *Homalomena* species [1], [19] [34]. This issue may lead due to inaccessible forest landform to determine the species distribution.

Planning conservation strategy is difficult without actual knowledge of the biological parameters that support the survival of a living things especially plants. International

Union for Conservation of Nature (IUCN) outline a proper framework of strategic planning for species conservation which listed severe steps that essential to be considered [12]. According to [12], precise data on the historical and current distribution of the species is very important at the beginning of the framework procedure before move to the next procedure. The flow of this procedure highlighted the importance of having an updated information on the distribution of a species. The main problem is to obtain the localities of each species. This situation occurs because of some circumstances such as accessibility to certain area because of geographical difficulty or the extreme forest landforms. Hence, it is really important to have a better technique to predict the potential distribution of a species.

Modeling species distribution offer more than just knowing the potential habitat of a species [10]. It also provides better understanding on the relation between species distribution and related environmental variables that contribute to the distribution of the species [9], [11], [24]. Recent years shown positive trend in the development of modeling species distribution techniques [10]-[11], [25], and ecological niche model (ENM) arose to be most preferable technique in estimating the species distributions [5], [9], [22], [28]. It is widely used in other ecological studies covering terrestrial, marine and also fresh water ecosystems of both animals and plants. These studies shown positive results in their studies, such as improved application in species delimitation techniques [28], predicting potential risk of invasive species [14], [23] evaluating niche stability [32], modeling potential spawning habitat for marine fish [30], assessing the habitat loss and species conservation status [7], [17]-[18].

2. Materials and Methods

2.1. Data Acquisition

2.1.1. Locality data

Previous study of Araceae in Kelantan summarized a total of seven species from the *Homalomena* genus were found. However, only five species were selected for this study, these are *Homalomena curvata* Engl., *H. griffithii* (Schott) Hook.f., *H. pontederifolia* Griff. ex Hook.f., *H. truncata* (Schott) Hook.f., and *H. wallichii* Schott. These five species were chosen based on the number of localities available, where species occurred in minimum five different localities in Kelantan.

2.1.2. Environmental variables

Modeling species distribution requires environmental layers in constructing the prediction of the potential suitable habitat, where the data used in this model usually stored in Geographical Information System (GIS) format [2], [6], [15], [17], [21], [26]. These environmental niches were used to determine the potential habitat condition [10], [21]-[22], [31]. Related bioclimatic datasets for Kelantan at 30 arc-second (~1km^2) was downloaded from WordClim website (http://www.worldclim.org/), which consist of nineteen bioclimatic variables (Bio1-Bio19). In addition, data on soil at 30 arc-second were downloaded from Harmonized World Soil Database (HWSD) (http://www.iiasa.ac.at/web/home/research/modelsData/HWSD/HWSD.en.html). In addition, altitude data was downloaded from processed Shuttle Radio Telemetry Mission (SRTM) data version 4.1. Finally, slope data was generated using ESRI ArcMap version 10.5.1 [13], [18].

2.2. Data Rectification

2.2.1. Locality data

The locality data were transformed to geographic coordinate system to match the occurrence record and environmental variables as Maxent able to read the locality data in longitude and latitude format [21]. One of the advantages of this modeling software is able to generate positive result even though with even small sample size [3], [8], [35]. Then, these longitude and latitude coordinates of *Homalomena* genus were converted from an Excel spreadsheet into a Comma-Separated Value (.csv) format as required [27], [36].

2.2.2. Environmental variables

The environmental layers as shown in Table 1 were undergo several modification process in order to standardize the projections, grid cell sizes and geographic bounds for every layers to be in the same extent [6], [18], [21], [36]. These environmental layers are larger than area of interest and were extracted based on Kelantan shape file using ArcMap version 10.5.1. Then, these shape file were converted into ESRI ASCII format using ArcMap Conversion Tools. Finally, these environmental layers were set in WGS84 projection.

Table 1: Environmental variables used in predicting potential suitable habitat for *Homalomena* genus of Araceae in Kelantan

No.	Environmental Variables
1.	Annual Mean Temperature
2.	Mean Diurnal Range (max. temp – min. temp)
3.	Isothermality (2/7)*100
4.	Temperature seasonality (standard deviation *100)
5.	Max. Temperature of Warmest Month
6.	Min. Temperature of Coldest Month
7.	Temperature Annual Range
8.	Mean Temperature of Wettest Quarter
9.	Mean Temperature of Driest Quarter
10.	Mean Temperature of Warmest Quarter
11.	Mean Temperature of Coldest Quarter
12.	Annual Precipitation
13.	Precipitation of Wettest Month
14.	Precipitation of Driest Month
15.	Precipitation of Seasonality
16.	Precipitation of Wettest Quarter
17.	Precipitation of Driest Quarter
18.	Precipitation of Warmest Quarter
19.	Precipitation of Coldest Quarter
20.	Soil data
21.	Altitude
22.	Slope

2.3. Data Analysis

As all the locality data and environmental layers were completely modified, the model were then generated using Maxent modeling software. Ecological niche model for *Homalomena* genus in Kelantan were generated using Maximum Entropy (Maxent) modeling of species geographic distributions version 3.3.3k (http://www.cs.princeton.edu/~schapire/maxent) [27]. Few alterations were made to the model setting such as number of replicate runs were set at 100 replications with 10,000 background points randomly selected per run [17]. Besides, the random test percentage were set at 0%, 25% and 75% for three different models, but only result for 0% random test percentage were chosen as it gives most accurate prediction.

3. Results and Discussion

The species distribution models for five species of *Homalomena* genus in Kelantan were shown in Figure 1. The distribution map uses different contrast colours in representing the prediction values. Red zone indicates high probability of suitable habitat for the species, while yellow and light green zone indicates medium and low probability respectively. Finally, dark green indicates very low prediction of habitat suitability. Besides, the prediction of the habitat suitability was classified into four different classes of habitat suitability: very low, low, medium, and high. These four classes of habitat suitability were categorized based on the probability range which ranging from 0 to 1 as follows: very low (0 - 0.2), low (0.2 - 0.4), medium (0.4 - 0.6), and high (0.6 – 1.0).

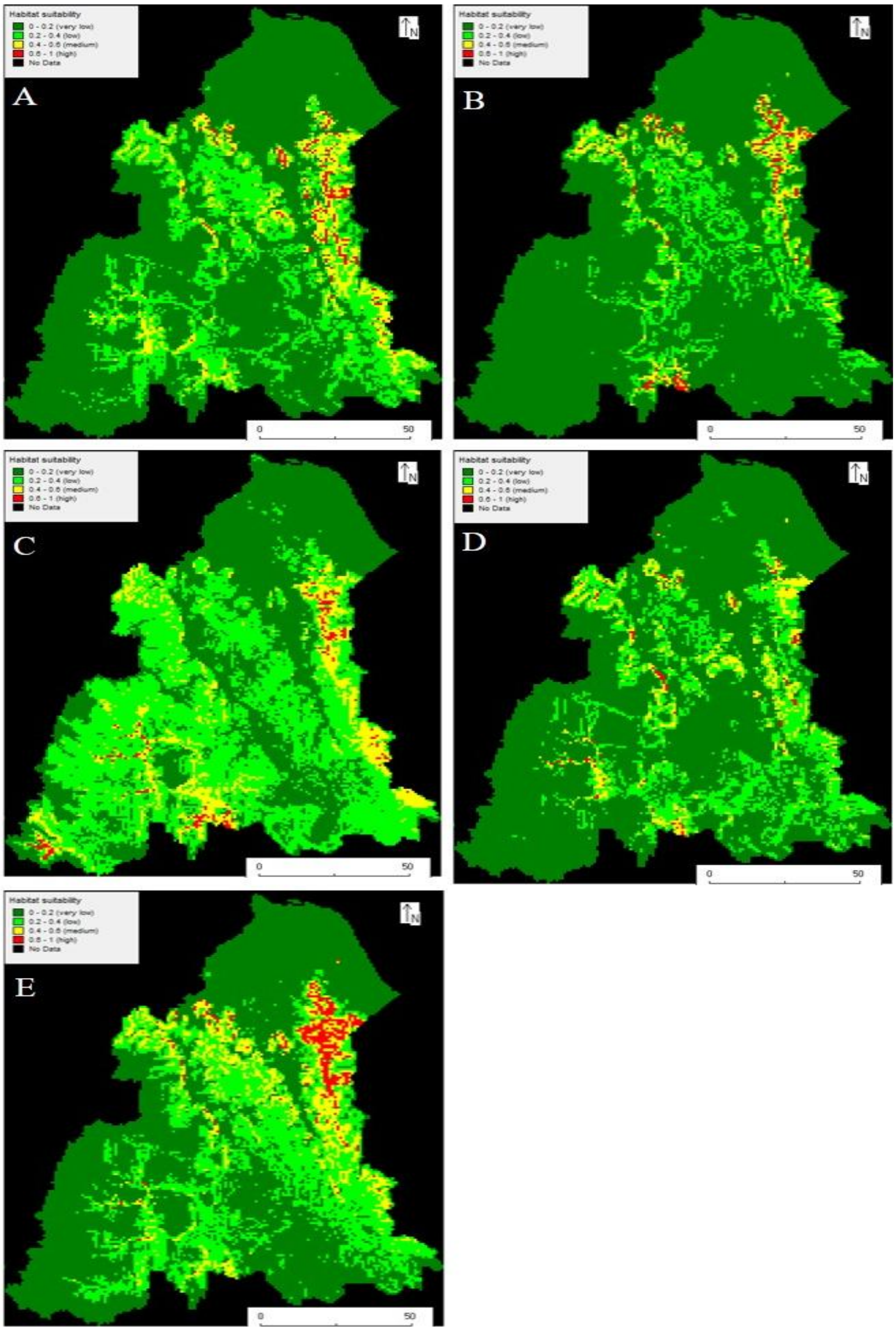

Figure 1: Predicted potential suitable habitat for selected *Homalomena* genus of Araceae in Kelantan. A) Habitat suitability for *H. curvata* Engl., B) Habitat

suitability for *H. griffithii* (Schott) Hook.f., C) Habitat suitability for *H. pontederifolia* Griff. ex Hook.f., D) Habitat suitability for *H. truncata* (Schott) Hook.f., E) Habitat suitability for *H. wallichii* Schott

The result shows that all five species in the northern part of Kelantan are very low of habitat suitability. This area is the most developed area in Kelantan where most of the forest was converted to other land uses (Figure 1). The high probability of habitat suitability is in east part of Kelantan covering districts of Pasir Puteh, Machang, west Kuala Krai, and Gua Musang. These areas still intact with forest. Besides that, these east part of Kelantan are located in altitude more than 300 m a.s.l. According to [16], this particular genus preferred to grow in lowland tropical forest and also can reach the mid montane zone with altitude ranging from 300 m to 1400 m a.s.l. In [37] stated that *Homalomena* genus distribution were also influenced by altitude factor as the species richness can reach up to 1500 m a.s.l. Hence, the predicted model can be considered as a good prediction.

Table 2 shows the percentage contribution of environmental variables used in predicting potential suitable habitat for *Homalomena* genus in Kelantan. Each species requires different variables for their own habitat distribution as referred to Table 2. Most of the species indicated slope as their major contribution. Three species have slope percentage of contribution as the highest environmental variable contributor. Another two species shown different trend in selecting the highest contributor that are *H. curvata* c.f. and *H. pontederifolia* Griff. ex Hook.f.

Table 2: Relative percentage contribution of environmental variables in MAXENT model for five species of *Homalomena* genus of Araceae in Kelantan

Environmental Variables	*H. curvata* Engl.	*H. griffithii* (Schott) Hook.f.	*H. pontederifolia* Griff. ex Hook.f.	*H. truncata* (Schott) Hook.f.	*H. wallichii* Schott
Annual Mean Temperature	6.2	2.8	1.9	0.6	6.1
Mean Diurnal Range (max. temp – min. temp)	1.7	0.1	0.6	0	2.3
Isothermality (2/7)*100	0.9	2.1	4.9	0.1	4.1
Temperature seasonality (standard deviation *100)	2.5	0.5	0.6	0.9	0.9
Max. Temperature of Warmest Month	3.3	2.1	1.8	3.1	4.3
Min. Temperature of Coldest Month	0.2	0.2	0.1	0.1	0.5
Temperature Annual Range	0.6	0.2	3.4	0	0.7
Mean Temperature of Wettest Quarter	0.7	3.1	9.1	1.3	3.0
Mean Temperature of Driest Quarter	1.5	1.0	1.0	0.4	0.8
Mean Temperature of Warmest Quarter	0.8	2.5	0	0.5	2.4
Mean Temperature of	1.4	0.6	0.3	1.6	0.8

Coldest Quarter					
Annual Precipitation	5.2	13.0	13.8	4.1	11.5
Precipitation of Wettest Month	12.4	11.0	13.8	10.8	5.4
Precipitation of Driest Month	0.1	0.2	1.3	1.0	1.6
Precipitation of Seasonality	12.7	9.5	4.8	8.1	10.2
Precipitation of Wettest Quarter	5.6	0.4	11.0	15.9	9.2
Precipitation of Driest Quarter	8.2	10.4	3.0	7.6	7.7
Precipitation of Warmest Quarter	0.1	1.1	2.7	0.8	0.3
Precipitation of Coldest Quarter	0.7	0.3	1.9	0.7	0.3
Soil data	6.2	2.4	5.7	10.8	3.1
Altitude	16	12.7	13.4	14.8	11.5
Slope	13.2	23.9	4.9	16.7	13.3

For the variables contributions results, each species shows different environmental variable as their major contributor. *H. griffthii* (23.9%), *H. truncata* (16.7%), and *H. wallichii* (13.3%) have slope as their higher environmental contributor that influenced their distribution. This situation indicates that most of *Homalomena* genus preferred habitat with sloppy area as their suitable habitat. A collection of Araceae done by [38] strongly supported this finding as they found these three species in a sloppy area.

The other two species show different variables as the major factor that influenced their distribution, which *H. curvata* with 16% altitude and *H. pontederifolia* with 13.8% precipitation. A study on Homalomena in Borneo by [39], showed that a new species from Homalomena supergroup chamaecladon was found in a lowland humid forest, shaded areas on rocky clay soil with altitude of 150 m. Another study on Homalomena in Borneo shows this genus preferred perhumid evergreen upperhill forest niche along small streams on elevation of 700 m a.s.l. [33]. Both studies showed some similarity on the required niches for this genus to grow in an area with high humidity and shaded condition. In contrast, both of the studies also discover different requirement such as different forest type according to the elevation. From these scenario, this genus has specific requirement on the environmental condition that support their growth, thus agreed with the Maxent second output concept. However, the remaining variables such as temperature, precipitation and soil gave minor impact on the prediction.

With advance technology in computer software and vast amount of secondary data or previous field data records, modeling species distribution play big important role in helping conservationist or biologist to find where the study species is located in natural habitat. Predicting species distribution is crucial at the first step in planning conservation strategies as it helps in indicating area that should be given priority for conservation [40]. In addition, in [41] proved that predicting species distribution range is very important in the preliminary stage of implementing conservation planning as it tells us where the species might possibly occur. Moreover, Maxent software, also best to be used for small occurrence data.

4. Conclusion

In conclusion, the results proved that ecological niche modeling approach using Maxent software can be used to predict the species distribution not only for five species of Homalomena in Kelantan, but also for other plant species. East part of Kelantan were predicted as the most suitable habitat for this genus to occur as this area is still intact with forest. The distribution of Homalomena genus in Kelantan were majorly influenced by several environmental factor such as sloppy habitat, different altitude range and precipitation.

Acknowledgments

We greatly thank numerous people and organisation for their contribution in completing this research. The research will not able be completed without dedicated plant collecting effort from previous researchers and staffs from Forest Research Institute Malaysia herbarium (KEP) and dedicated collectors from Universiti Malaysia Kelantan who did assessments on the diversity and abundance of Araceae in Kelantan. Besides, this work was fully supported by research grant scheme Research Acculturation Collaborative Effort (RACE) R/RACE/A08.00/00131A/0012014/000158.

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