Predicting the current potential geographical distribution of Baccaurea (B. lanceolata and B. motleyana) in South Kalimantan, Indonesia

by Gunawan Gunawan

Submission date: 15-Aug-2024 11:03AM (UTC+0700)
Submission ID: 2432262739
File name: the_current_potential_geographical_distribution_of_Baccaurea.pdf (1,022.67K)
Word count: 7645
Character count: 42529

BIODIVERSITAS
Volume 24, Number 2, February 2023
Pages: 930-939

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d240232

Predicting the current potential geographical distribution of *Baccaurea* (*B. lanceolata* and *B. motleyana*) in South Kalimantan, Indonesia

GUNAWAN[1,♥], KHOERUL ANWAR[2], ABDUL GAFUR[1], RAUDATUL HILALIYAH[1], AZMIL AQILATUL WARO[1], NUR HIKMAH[1], SAKINAH[1], MUHAMMAD ERWANSYAH[1], DIAN SUSILAWATI[1], RATNA DWI LESTARI[1], DINDA TRIANA[1]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Lambung Mangkurat. Jl. A. Yani Km 36.4, Banjarbaru 70714, South Kalimantan, Indonesia. Tel./fax.: +62-511-4773112, ♥email: gunawan@ulm.ac.id

[2]Department of Pharmacy, Faculty of Mathematics and Natural Sciences, Universitas Lambung Mangkurat. Jl. A. Yani Km 36.4, Banjarbaru 70714, South Kalimantan, Indonesia. Tel./fax.: +62-511-4773112

Manuscript received: 21 November 2022. Revision accepted: 7 February 2023.

Abstract. *Gunawan, Anwar K, Gafur A, Hilaliyah R, Waro AA, Hikmah N, Sakinah, Erwansyah M, Susilawati D, Lestari RD, Triana D. 2023. Predicting the current potential geographical distribution of* Baccaurea (B. lanceolata *and* B. motleyana) *in South Kalimantan, Indonesia. Biodiversitas 24: 930-939.* *Baccaurea lanceolata* and *B. motleyana* are underutilized species of Kalimantan fruit tree but are a potential source of food and medicine. However, little is known about the occurrences and potential geographical distribution of *B. lanceolata* and *B. motleyana*. This study aimed to predict the potential geographical distribution of *B. lanceolata* and *B. motleyana* using MaxEnt, and understand the key factors which influenced their distribution. In addition to 19 bioclimatic factors, occurrence data for 57 *B. lanceolata* and 87 *B. motleyana* were gathered from field surveys. Solar radiation, altitude, and slope were then utilized to estimate the distribution of these species. Jackknife test was used to evaluate the importance of the environmental variables for predictive modeling. The Area Under Curve (AUC) values of *B. lanceolata* and *B. motleyana* were 0.927 and 0.851, indicating that the model is a good and informative model for species distribution of these species. The models for *B. lanceolata* suggest that the distribution is mainly influenced by altitude, temperature seasonality, precipitation of the wettest month, and precipitation of the driest quarter. Temperature, annual range, precipitation of the wettest month, precipitation of the coldest quarter, and solar radiation in July were the key environmental factors influencing the distribution of B. motleyana. The potential geographic distribution of *B. lanceolata* and *B. motleyana* can be useful information to help the researcher in restoration and conservation planning.

Keywords: *Baccaurea lanceolata*, *Baccaurea motleyana*, habitat suitability, MaxEnt, species distribution

INTRODUCTION

Although the genus *Baccaurea* includes fruit-producing plants, its existence is not as well known as that of other fruit-producing plants. In addition to using the fruit as fresh fruit and wood as building materials, members of the genus *Baccaurea* have been used by the community as medicinal plants to treat several diseases, including constipation, swelling of the eyes, arthritis, abdominal pain, and facilitating menstruation and urination (Usha et al. 2014; Ullah et al. 2012; Goyal et al. 2014; Lim 2012; Gunawan et al. 2016).

Baccaurea lanceolata, as locally known as "Limpasu" and *Baccaurea motleyana,* as locally known as "Rambai" are two species from the genus *Baccaurea* Family, Phyllanthaceae that have great potential as a medicinal ingredient. Antioxidant activity test with three methods (DPPH, ABTS, and FRAP) on the pericarp, fruit, flesh, and seeds of *B. lanceolata* showed high antioxidant activity, with the highest activity found in the flesh of the fruit (Bakar et al. 2014). Zamzani and Triadisti (2021) revealed that *B. lanceolata* has high antioxidant activity. The ethanol extract from spleen fruit was the most active extract against bacteria (Fitriansyah et al. 2018; Galappathie et al. 2014). Local communities in South Kalimantan used the extracted fruit of Limpasu as cosmetics as sunscreen. Fruit of *B. Lanceolata* also contains fenol, flavonoids, antosianin, and karotenoid (Bakar et al. 2014). *Baccaurea motleyana* has high antioxidant activity containing phenolic, flavonoid, and anthocyanin compounds, secondary metabolite compounds derived from sugar metabolism. Fitri et al. (2016) revealed that *B. motleyana* fruit contains phenols and flavonols and has lipid peroxidation activity. *Baccaurea motleyana* fruits have relatively low amounts of fats, organic acids, phenolics, and antioxidants compared to many other familiar fruits. *Baccaurea motleyana* tree parts were found to exhibit antidiabetic, antibacterial, and skincare properties (Prodhan and Mridu 2021).

Although *B. lanceolata* and *B. motleyana* have high utility value, habitat loss and population declines of these species continue to occur. Little is known about the occurrence of *B. lanceolata* and *B. motleyana* and their adaptability to different climates and edaphic conditions in South Kalimantan. The latest publication by Haegens (2000) stated *B. lanceolata* and *B. motleyana* were found in Borneo. Agricultural clearing, forest fires, illegal logging, forest conversion, increasing human population, and mining are important factors causing decreasing plant population and biodiversity loss. Budiharta et al. (2011) state that in Kalimantan region, habitat loss of many tree species is caused by continuous illegal logging, development of human settlements, agriculture, perennial crops, and timber plantations. In addition to environmental degradation brought on by numerous human activities, climate change also threatens the diversity of the current plant species (Hagacem et al. 2008). Climate change is also known as one of the most important factors influencing the geographic distribution of plant species (Forman 1964). Detailed information about the regional distribution of a plant is needed for its restoration and habitat conservation. Furthermore, information about a plant's distribution is important in determining the population, taxonomic variation, habitat suitability, and potential utilization. Studying the current and potential distribution of species and examining the key environmental factors that affect their growth can help us to understand the overall distribution patterns of species.

The Species Distribution Models (SDMs) is a general approach for investigating the potential distribution of species and suitable habitats in the environment. It is widely used for broad applications in ecology, biogeography, and conservation biology. A number of SDMs have been developed to estimate the suitable areas for specific species according to the specific algorithms, including Maximun Entropy (Phillips et al. 2006; Martinez-Minaya et al. 2018). MaxEnt is one of the SDMs programs based on environmental variables and species occurrence data, which is integrated by machine learning and the principle of maximum entropy to predict the potential distribution of species (Elith et al. 2011). The MaxEnt program has been used extensively to predict species distribution, which has also been employed by studies in South Asia (Pradhan 2015), including Indonesia (Setyawan et al. 2017, 2020a, 2020b, 2021; Gunawan et al. 2021a, 2021b; Usmadi et al. 2021; Harapan et al. 2022). Compared to other SDMs programs, MaxEnt can produce better models, because MaxEnt can create models only with occurrence data (Elith et al. 2011; Jackson and Robertson 2011; Kalboussi and Achour 2017), and it has the ability to run with a small amount of data (Fois et al. 2018; Préau et al. 2018). Furthermore, the results are highly accurate and highly reproducible (Fourcade et al. 2014).

The aim of this study was to predict the current potential distribution of *B. lanceolata* and *B. motleyana* in South Kalimantan, Indonesia and to identify the key factors including climatic and topography responsible for the distribution of these species. We expect the results of this study to provide information regarding the potential distribution of *B. lanceolata* and *B. motleyana* in Kalimantan, and identify the currently suitable areas for conservation and cultivation.

MATERIALS AND METHODS

Study area and species occurrence data

The study was conducted in South Kalimantan, Indonesia, which consists of 13 districts that have approximately 34.744 km^2 of land area. The geographic scope of this study includes the area of approximately 1°21'49" LS - 1°10'14" LS and 114°19'33" BT - 116°33'28". Authors collected the occurrence data of *B. lanceolata* and *B. motleyana* from local communities and forestry services (Figure 1). The explorative field survey was carried out according to the previous research method conducted by Rugayah et al. (2004). The field study period was from February to June 2022. Plant samples were collected and herbarium specimens were deposited in Bio-systematic laboratory Lambung Mangkurat University, South Kalimantan. Using Garmin 64s GPS series, we collected 57 occurrences points of *B. lanceolata* and 87 occurrences points of *B. motleyana* which were found distributed in South Kalimantan. All coordinates from the field survey were converted to decimal degrees and imported into Microsoft Excel, and then saved in CSV format. The coordinate data were used to describe the distribution of *B. macrocarpa* in the province of South Kalimantan using the DIVA Gis 7.5 software (Figure 2) and is used as input data for habitat suitability modeling using MaxEnt.

Climatic variables

For this study, we used 19 bioclimatic variables (11 temperature and 8 precipitation variables), solar radiation (12 months), altitude, and geo-slope were downloaded and assessed (Tabel 1). Bioclimatic variables were extracted from WorldClim (https://www.worldclim.org) (Hijsmans 2020). Slope variable was downloaded from www.fao.org (https://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/). In addition, a raster file of digital elevation models based on the altitude data is also downloaded from the WordClim website. They were generated through interpolation of average monthly climate data from weather stations at 30 arc seconds (*1 km) spatial resolution (Ficks and Hijmans 2017). All predictor variables layers were in GeoTIFF format, QuantumGis ver 2.8.10 was used to convert bioclimatic variables and environmental layers into an ASCII format for use in MaxEnt (Setyawan et al. 2020a).

Species distribution models require selecting and using environmental factors with a major influence on the model (Worthington et al. 2016) and with minimal inter-correlation (Pradhan 2016, 2019) to get an accurate and informative model. The variable selection was done with two-pronged approach. i) Firstly, Variance Inflation Factor (VIF) analysis was carried out across all bioclimatic variables in R platform. The pair-wise VIF values of bioclimatic variables were assessed and those variables were screened whose pair-wise VIF was <10. ii) Secondly, screened bioclimatic variables, along with another environmental factor, such as solar radiation, were put to Jackknife test evaluation for assessment of the contribution of each environmental variable to the resulting model.

The contribution percentage and permutation are two important factors for understanding and measuring the environmental variable's contribution as well as its importance to the model. According to the Jackknife test evaluation of the contribution of each environmental variable to the resulting model, twelve environmental variables were not used, eleven of them due to the lack of contribution to the model making 0% percent contribution and bio 8 due to co-linearity with bio 10 through VIF value of 63.8 (Pradhan 2016, 2019), and as well exclusion of bio 8 led to increasing in regularized training gain. Besides that, variables with a small average contribution (<6%) or permutation importance (<6%) were not used due to a lack of contribution to the models (Wei et al. 2018). Therefore, the final environmental variables used in *B. lanceolata* species distribution models map for the current period were alt (altitude), bio 4 (temperature seasonality), bio 13 (Precipitation of wettest month), bio 17 (Precipitation of driest quarter), whereas the final environmental variables for *B. motleyana* were bio 7 (Temperature annual range), bio 13 (Precipitation of wettest month), bio 19 (Precipitation of coldest quarter), srad 7 (Solar radiation in July). Variables that considered affecting the distribution of these species, i.e, land use, human disturbances, species dispersal or biotic interaction change were not included in the model because the availability of these data was limited.

Species distribution modeling

Several programs or algorithms have been developed to predict models of potential species distribution areas consisting of DOMAIN, Climatic Envelope (BIOCLIM), Generalized Linear Models (GLM), Artificial Neural Network (ANN), and Maximum Entropy (MAXENT). DOMAIN is a simple and straightforward model for modeling the distribution of plant species based on a range-standardized and point-to-point similarity matrix (Carpenter 1993). BIOCLIM is a climate-envelope model that has been widely used in species distribution modeling (Booth et al. 2014). BIOCLIM uses easy-to-understand algorithms and provides useful insight into methods and procedures of species distribution modeling (Hijmans and Graham 2006). GLM is a regression-based technique that is often used to predict biodiversity distribution (Guisan et al. 2017). Artificial Neural Network (ANN) is a machine learning approach that commonly tends to have better models' performance in predicting species distribution patterns. It is widely used in remote sensing image classification and ecological applications (Benediktsson et al. 1993). ANN works with both regression and classification, in addition, a continuous and categorical predictor can be used in this model. Each program has different theoretical foundations, required data, and analysis methods.

Several studies have shown that compared to other species distribution models, MaxEnt not only has good prediction and stability but also has the advantages of simple and fast operation, a small number of occurrences demanded (Yang et al. 2014; Beck et al. 2018; Song et al. 2020; Anand et al. 2021), and it works very well for presence-only data (Phillips et al. 2006). Maxent builds a prediction model based on the actual distribution points and environmental variables of the distribution area stored in the GIS and then Maxent will simulate the species distribution in the targeted location or region (Zhang et al. 2021).

We used MaxEnt version 3.4.1 (Phillips et al. 2017) to predict the current potential geographic distribution of *B. lanceolata* and *B. motleyana* in South Kalimantan. The software was downloaded from https://biodiversityinformatics.amnh.org/open_source/maxent and can be extracted freely for scientific research. In our predicted models, the default setting was used in MaxEnt model (Abdelaal et al. 2019). We employed 10 replicates and the average probability for habitat suitability of *B. lanceolata* and *B. motleyana* in South Kalimantan (Hoveka et al. 2016). The bootstrap method was implemented with 10 repeats, a maximum of 5000 iteration, and default selected parameters (Yan et al. 2020). Models resulting from MaxEnt were evaluated; the accuracy and quality of the model used the Area Under the Curve (AUC) scores of Receiver Operating Curve (ROC) analysis. The scores of AUC ranged from 0.5 to 1. An AUC score of 0.5 indicates the model prediction did not perform better than random expectation, while a score of 1.0 shows the resulting model is very good and informative (Swets 1988). We also performed the Jackknife test. A Jackknife analysis was used to calculate the contribution of the variables for the model prediction for *B. lanceolata* and *B. motleyana*. Jackknife analysis is also carried out to determine the dominant variables that determine the potential distribution of species (Yang et al. 2013). In addition, we used response curves that produced by MaxEnt analysis to know the relationship between the habitat suitability of *B. lanceolata* and *B. motleyana* and environmental factors.

The results of Maxent's analysis of *B. lanceolata* and *B. motleyana* were imported into DIVA GIS software version 7.5 (Hijmans et al. 2012) for visualization and further data analysis. The species distribution models map resulting from MaxEnt has suitability levels that can be grouped into 4 classes, namely, least suitable (0.0-0.2), low suitability (0.2-0.4), medium suitability (0.4-0.6), and high suitability (0.6-1.0) (IPCC 2007; Ji et al. 2020).

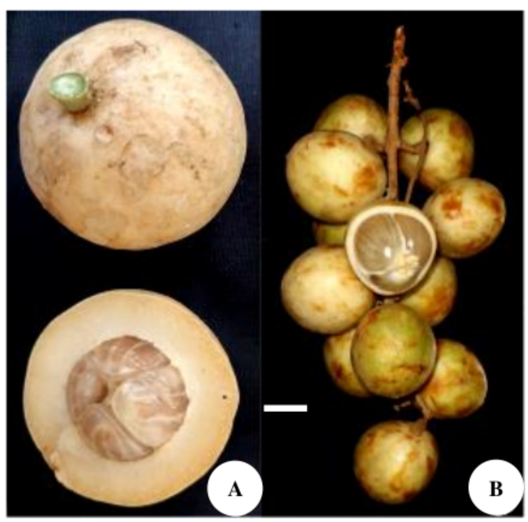


Figure 1. Fruit of *Baccaurea* species. A. *Baccaurea lanceolata*, B. *Baccaurea motleyana*. Bar = 1 cm

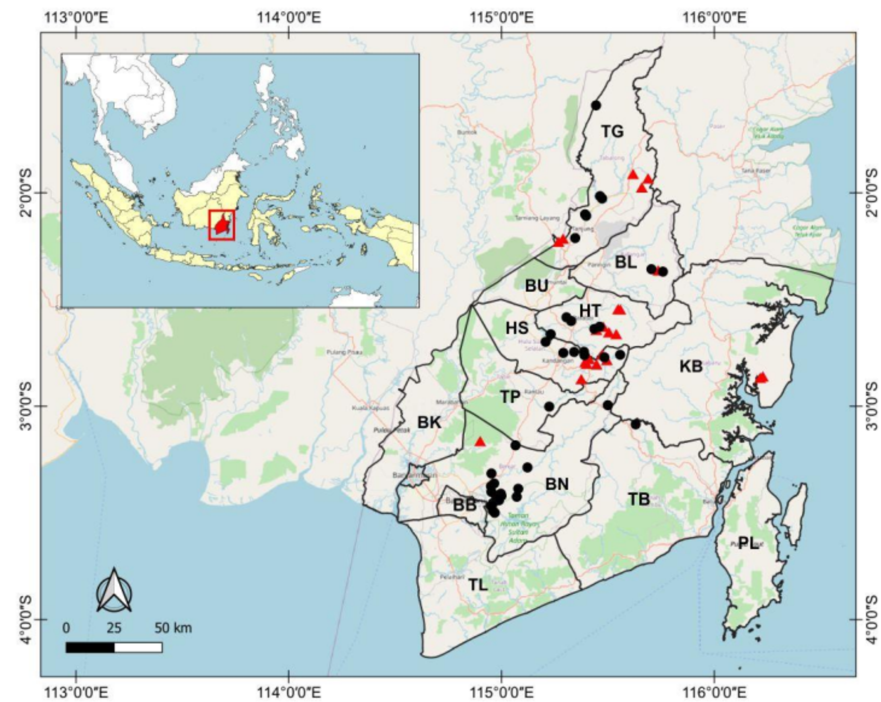


Figure 2. Current distributions of *B. Lanceolata* and *B. motleyana* in South Kalimantan obtained from field survey. TL: Tanah Laut; TB: Tanah Bumbu; PL: Pulau Laut; BB: Banjar Baru; BN: Banjar; BK: Barito Kuala; TP: Tapin; KB: Kota Baru; HS: Hulu Sungai Selatan; HT: Hulu Sungai Tengah; HU: Hulu Sungai Utara; BL: Balangan; TG: Tabalong

Table 1. Description of environmental variables used for MaxEnt model prediction for *B. lanceolata* and *B. motleyana*

Code	Parameter	Unit
Alt	Altitude	m
Srad	Solar radiation (12 month)	w/m^2
gloslope	Slope	
bio 1	Mean annual temperature	ºC
bio 2	Mean diurnal range (max temp - min temp)	ºC
bio 3	Isothermality	ºC
bio 4	Temperature seasonality	ºC
bio 5	Maximum temperature of warmest month	ºC
bio 6	Minimum temperature of coldest month	ºC
bio 7	Temperature annual range	ºC
bio 8	Mean temperature of wettest quarter	ºC
bio 9	Mean temperature of driest quarter	ºC
bio 10	Mean temperature of driest quarter	ºC
bio 11	Mean temperature of coldest quarter	
bio 12	Annual precipitation	mm
bio 13	Precipitation of wettest month	mm
bio 14	Precipitation of driest month	mm
bio 15	Precipitation seasonality	mm
bio 16	Precipitation of wettest quarter	mm
bio 17	Precipitation of driest quarter	mm
bio 18	Precipitation of warmest quarter	mm
bio 19	Precipitation of coldest quarter	mm

RESULTS AND DISCUSSION

Model performance

Many researchers use the Area Under the Curve (AUC) statistic to evaluate the final model (Setyawan et al. 2017, 2020a, 2020b, 2021; Pradhan 2015; Gunawan et al. 2021a; Gunawan et al. 2021b; Romadlon et al. 2021; Shao et al. 2022). Model performance was classified as failing (0.5-0.6), poor (0.6-0.7), fair (0.7-0.8), good (0.8-0.9), and excellent (0.9-1) (Araujo et al. 2005). Our model output by MaxEnt provided satisfactory results with the AUC training value for *B. lanceolata* 0.926 and for *B. - motleyana* AUC value is 0.851, which is higher than 0.5 of a random model. The final model indicated a good model and had high accuracy for species distribution models (Figure 3). This indicates that the environmental variables were well selected to predict the current potential geographic distribution of *B. lanceolata* and *B. motleyana*. In this study, we determine the key environmental variable based on their contributions to the modeling process. The Jacknife test was conducted to show the influence of each environmental variable in building the model (Figure 3).

Altitude, temperature, and precipitation were the most important environmental for *B. lanceolata,* while for *B. motleyana* were temperature, precipitation, and solar radiation (Table 2). Altitude was the highest contributing influencing the predicted distribution for *B. lanceolata* ranging from 0-200 m asl with a peak at ~180 m asl. The environmental variable that greatly influenced the predicted distribution for *B. motleyana* was the annual temperature range, with the optimum temperature annual range between 9ºC and 11.5ºC. Analysis of environmental variable contributions is different between species so the different species have different species distribution models.

Variables' response curves

The response curves were presented to show a relationship between the probability of *B. lanceolata* and *B. motleyana* distribution with environmental variables can be seen in the response curve generated by the Maximum Entropy model. Response curves show the quantitative relationship between environmental variables and the logistic probability of presence and they deepen the understanding of the ecological niche of the species (Yi et al. 2016). Species response curves also show biological tolerances for target species and habitat preferences (Gebrewahid et al. 2020). The response curves of *B. lanceolata* and *B. motleyana* to four environmental variables are illustrated in Figures 4A and 4B.

The response curves of *B. lanceolata* to four environmental variables are shown in Figure 4A. Based on the response curves, the suitable altitude range (Alt) of *B. lanceolata* ranged from 0-200 m asl with a peak at ~180 m asl. The next important environmental variable was the precipitation of the wettest month (bio 13) which showed 300-320 mm, with a peak at ~319 mm. The response curve of bio 4 showed that the suitable temperature seasonality ranged from 22ºC-28ºC and peaked at ~27.5ºC. The optimal precipitation of the driest quarter which showed a range of 250-500 mm and a peak at ~425 mm required by *B. lanceolata* was indicated by the response curve of bio 17. The response curves of *B. motleyana* to four environmental variables are shown in Figure 4B. According to the response curve, the optimum temperature annual range (bio 7) for *B. motleyana* ranged between 9ºC and 11.5ºC. The next important environmental variable for *B. motleyana* was solar radiation in July (srad 7) which showed a range of 16000-18000 w/m^2, with a peak at ~17687 w/m^2. The optimal precipitation of the wettest month which showed a range of 290-320 mm and a peak at ~310 mm required by *B. motleyana* was indicated by the response curve of bio 13. The response curve of bio 19 showed that the suitable precipitation of the coldest month (bio 19) ranged from 300-1100 mm and peaked at ~1090 mm.

The results of the model showed that altitude, temperature, solar radiation, and precipitation were the dominant environmental variables for the habitat suitability of *B. lanceolata* and *B. motleyana*. Geographical variables such as altitude often correlate with local precipitation and temperature (Austin 2002; Körner 2007). Temperature has an important role in maintaining the humidity in the local region by regulating evapotranspiration levels. Solar radiation is the main source of energy for organisms in the ecosystem. Solar radiation affects the plant's physiological processes, especially in plant growth and development. Solar radiation also affects climate, plant growth and evolution, vegetation distribution, and succession, and productivity in the forest ecosystem (Jordan et al. 2005; Li et al. 2011; Fyllas et al. 2017). Climates have a significant role in the distribution of plant species (Svenning and Sandel 2013). Precipitation is one of the environmental variables that have an important role in the habitat suitability of *B. lanceolata* and *B. motleyana*. Precipitation plays a major role as an element in plant development (Dasci at al. 2010).

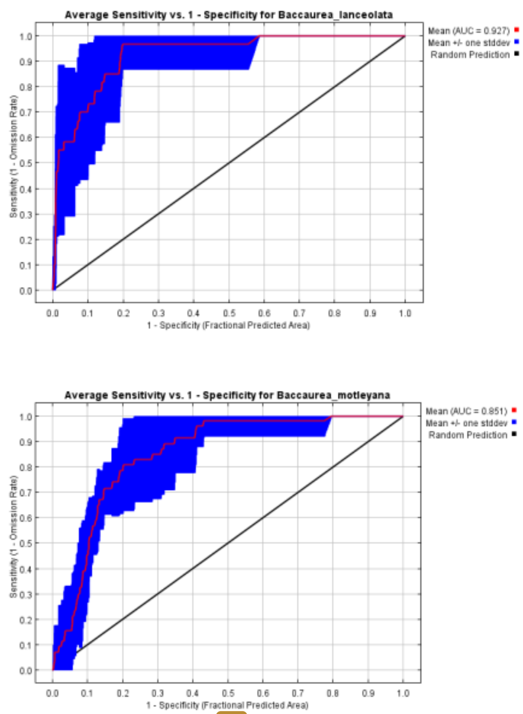


Figure 3. Result of area under the receiver operating characteristics curve (ROC-AUC) analyses for a MaxEnt model of habitat suitability for *Baccaurea lanceolata* and *Baccaurea motleyana*

Table 2. Environmental variable contribution for *B. lanceolata* (Bl) and *B. motleyana* (Bm)

Code	Environmental variable	Contribution (%)	
		Bl	Bm
Alt	Altitude	24.4	-
bio 4	Temperature seasonality	15.7	-
bio 7	Temperature annual range	-	34.6
bio 13	Precipitation of wettest month	10.6	15
bio 17	Precipitation of driest quarter	22.2	-
bio 19	Precipitation of coldest quarter	-	7.3
srad 7	Solar radiation in July	-	10.7

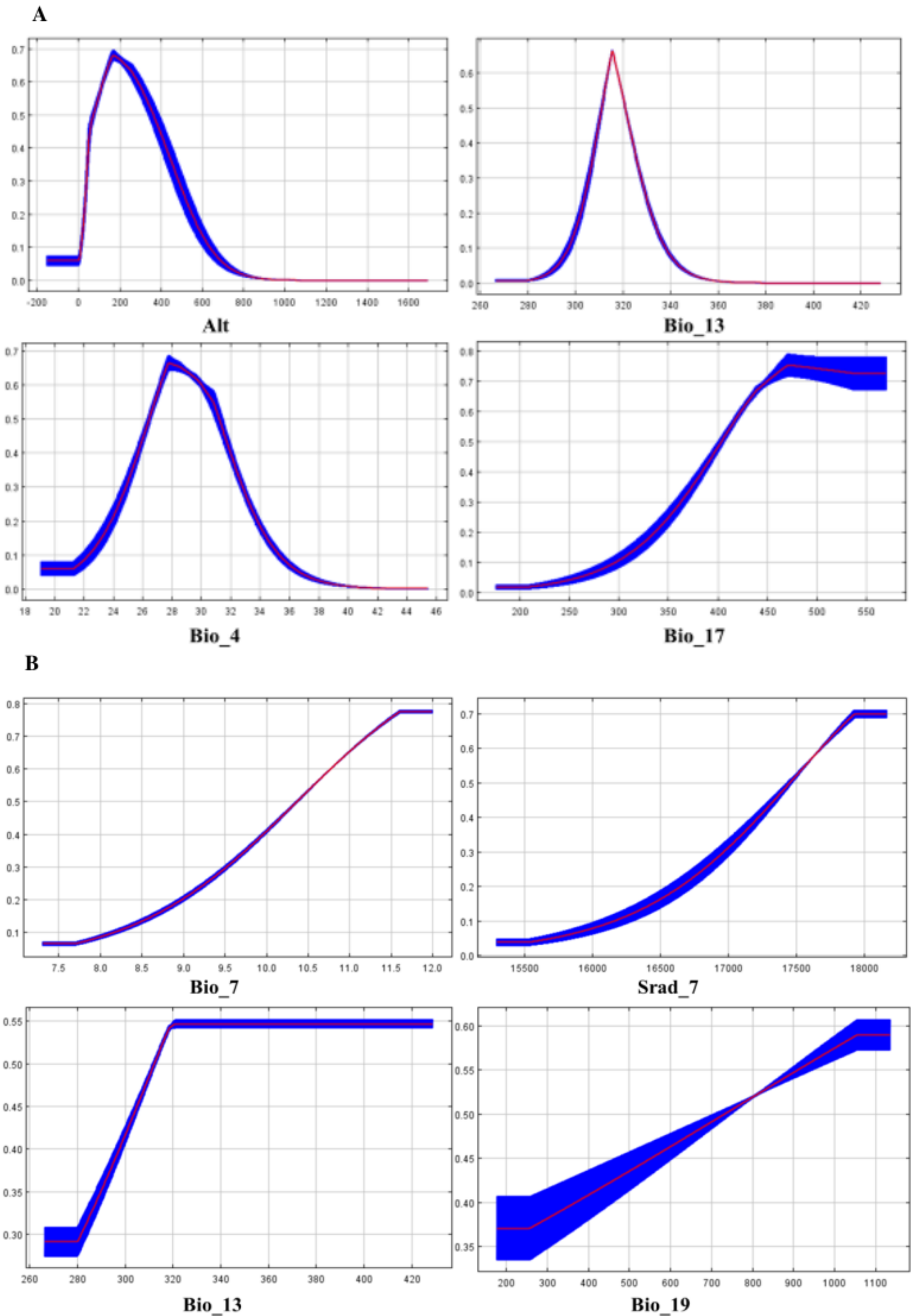


Figure 4. Response curves to four key environmental variables. A. response curve for *B. lanceolata*: Alt: Altitude; Bio 13: Precipitation of wettest month; Bio 4: Temperature seasonality; Bio 17: Precipitation of driest quarter. B. response curve for *B. motleyana*. Bio 7: Temperature annual range; Srad 7: Solar radiation in July; Bio 13: Precipitation of wettest month; Bio 19: Precipitation of coldest quarter. The curves show the mean response of the 10 replicate MaxEnt runs (red) and the mean +/- one standard deviation (blue, two shades for categorical variables)

The previous research on species *Baccaurea* (Gunawan et al. 2021a; 2021b) also revealed that altitude, temperature, solar radiation, and precipitation were also influenced by distribution range. This shows that environmental variables such as altitude, temperature, solar radiation, and precipitation play an important role in *Baccaurea* habitat. Climatic factors such as temperature and precipitation were affecting the distribution (Belguidoum et al. 2021). Zhang et al. 2018, also state that climatic factors are crucial factors that affect plant regeneration, growth, and the spread of its populations.

Prediction of current potential distribution

Baccaurea is an underutilized plant, but this fruit has benefits as a source of medicinal ingredients and as well as important ecological functions as the fruits are eaten by many bird species, but also by rodents, deer, and monkeys (Rijksen 1978). Little is known about the existence and distribution of *B. lanceolata* and *B. motleyana* in South Kalimantan. The model prediction of the potential distribution of *B. lanceolata* and *B. motleyana* was created based on the observed occurrences and current climate conditions. The maps of species distribution models produced by MaxEnt and categorized into four suitability classes between 0 to 1 are presented in Figure 5.

The greatest concentration of highly suitable areas for *B. lanceolata* (IHS 0.6-1) was mainly predicted in six districts (*kabupaten*): BN (Banjar), HS (Hulu Sungai Selatan), HT (Hulu Sungai Tengah), BL (Balangan), PL (Pulau Laut), and TG (Tabalong). Other locations that have high and medium habitat suitability (IHS 0.4-0.6) were BN (Banjar), BL (Balangan), TG (Tabalong), TB (Tanah Bumbu), and PL (Pulau Laut). The lowly suitable habitat (IHS 0.2-0.4) was predicted in a part of TG (Tabalong), BL (Balangan), PL (Pulau Laut), TB (Tanah Bumbu), and BN (Banjar). The least levels of habitat suitability for *B. lanceolata* (IHS 0.0-0.2) were predicted in TL (Tanah Laut), BB (Banjarbaru), BK (Barito Kuala), TP (Tapin), a part of HU (Hulu Sungai Utara), HT (Hulu Sungai tengah), PL (Pulau Laut) and TB (Tanah Bumbu).

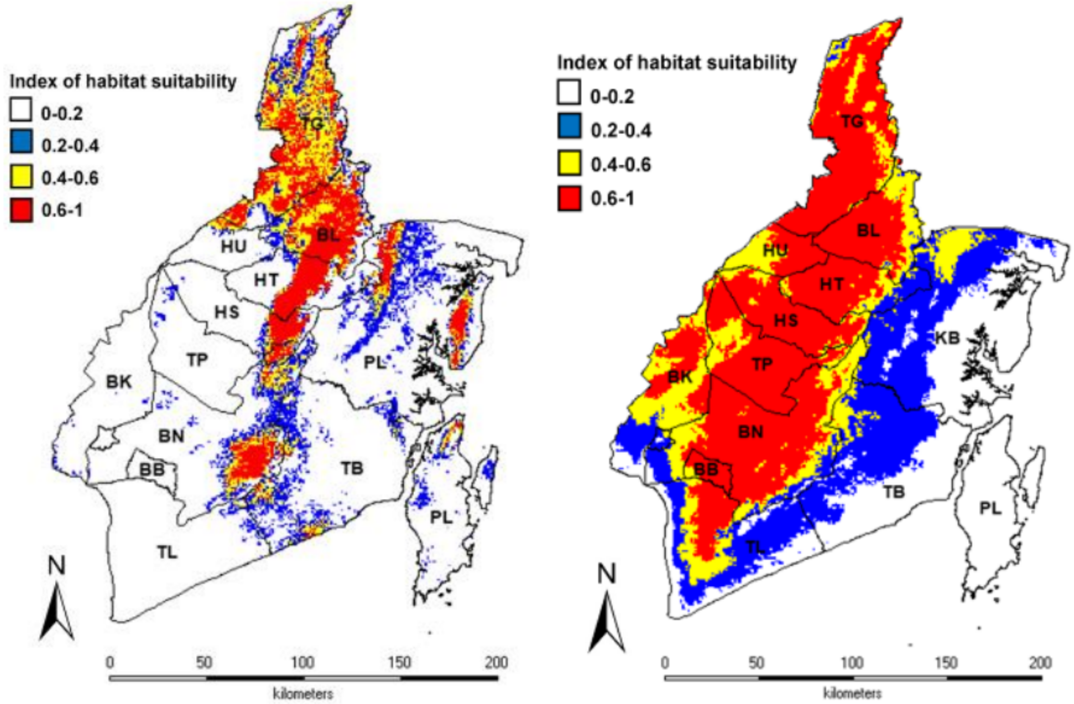
The greatest concentration of highly suitable areas for *B. motleyana* (IHS 0.6-1) was mainly predicted in nine districts (*kabupaten*): TG (Tabalong), BL (Balangan), HT (Hulu Sungai Tengah), HU (Hulu Sungai Utara), HS (Hulu Sungai Selatan), BN (Banjar), BB (Banjarbaru), and BK (Barito Kuala). Other locations that have high and medium habitat suitability (IHS 0.4-0.6) were a part of TG (Tabalong), BL (Balangan), HT (Hulu Sungai Tengah), HU (Hulu Sungai Utara), TP (Tapin), BN (Banjar), BK (Barito Kuala), TL (Tanah Laut), and KB (Kota Baru). The lowly suitable habitat (IHS 0.2-0.4) was predicted most a part of BK (Barito Kuala), TL (Tanah Laut), TB (Tanah Bumbu), and KB (Kota Baru). The least levels of habitat suitability for *B. lanceolata* (IHS 0.0-0.2) were predicted in BK (Barito Kuala), TL (Tanah Laut), TB (Tanah Bumbu), KB (Kota Baru), and PL (Pulau Laut).

The MaxEnt models under current climate conditions show that *B. lanceolata* distribution ranges are more influenced by altitude, temperature (seasonal temperature), and precipitation (driest month and driest quarter). Whereas *B. motleyana* distribution range was more influenced by temperature (temperature annual range), solar radiation (solar radiation in July), and precipitation (precipitation of the wettest month and precipitation of the coldest quarter). Temperature, solar radiation, precipitation and soil properties are important factors that influence plant species distribution (Hemp 2006).

In addition to environmental variables, species distribution and modeling may also be influenced by biotic factors, speciation mechanisms and dispersal ability (Kaky et al. 2020). *Baccaurea lanceolata* has a narrower habitat suitability area compared to *B. motleyana* based on MaxEnt's final model. Based on field observations, *B. lanceolata* is often found at an altitude of 110-150 m asl. This has a positive correlation with environmental factors that have a large influence on the model produced by MaxEnt, as indicated by the response curve that is altitude.

Despite the fact that the genus *Baccaurea* is underutilized by local communities, it has great potential as a source of medicinal ingredients (Gunawan et al. 2016). SDMs can provide a new understanding of the ecological conditions required by *B. lanceolata* and *B. motleyana*, and also identify conservation areas for both species. The distribution and presence of *B. lanceolata* and *B. motleyana* in South Kalimantan is not well known. Therefore, habitat suitability distribution maps of *B. lanceolata* and *B. motleyana* are valuable resources for researchers and conservationists in determining locations for the conservation or cultivation of these plants. In the case of Indonesia, especially in the Kalimantan region, continuous illegal logging, settlement development, agriculture, annual crops, and timber plantations have been causing habitat loss for many tree species (Budiharta et al. 2011). As a result, rather than being converted to plantations or settlements, sites with a high degree of suitability are retained or prioritized, allowing for the conservation and cultivation of these plants.

Climate has long been recognized as one factor influencing plant species' distribution (Forman 1964). One of the impacts of climate change on plant species is that plants may shift to higher elevations in response to which they are adapting (Parmesan 2006). In addition, the impact of climate change on plants is to affect the life cycle of plants, affect flowering time, and reproduction time, and ultimately can affect the diversity of plant species (Thuiller et al. 2008; Belgacem et al. 2008; Hilbish et al. 2010; Hill and Preston 2015). For example, climate change affects the flowering and fruiting season of the genus *Baccaurea*. The literature shows that *Baccaurea motleyana* flowers from January to May, August, October, and November. This species fruits in January, May, July to September, November, and December (Haegens 2000). However, based on field observations, *B. motleyana* in South Kalimantan flowers in August and October and fruits in September, November, and December. The flowering season of *B. lanceolata*, which should be March to December, according to Haegens (2000), based on observations in South Kalimantan, flowered from June to December. The fruiting season for *B. lanceolata* from observations, which is fruiting throughout the year, has not changed compared to Haegens (2000) literature, which is fruiting throughout the year.



A B

Figure 5. Map of potential current habitat suitability according to occurrence records in South Kalimantan. A. *Baccaurea lanceolata*. B. *Baccaurea motleyana*. TL: Tanah Laut; TB: Tanah Bumbu; PL: Pulau Laut; BB: Banjar Baru; BN: Banjar; BK: Barito Kuala; TP: Tapin; KB: Kota Baru; HS: Hulu Sungai Selatan; HT: Hulu Sungai Tengah; HU: Hulu Sungai Utara; BL: Balangan; TG: Tabalong

ACKNOWLEDGEMENTS

The authors would like to thank LPDP of the Ministry of Education, Culture, Research and Technology, Republic of Indonesia, for providing *Riset Mandiri* grant which has funded this research.

REFERENCES

Abdelaal M, Fois M, Fenu G, Bacchetta G. 2019. Using MaxEnt modeling to predict the potential distribution of the endemic plant *Rosa arabica* Crép in Egypt. Ecol Inform 50: 68-75. DOI: 10.1016/j.ecoinf.2019.01.003.

Anand V, Oinam B, Singh IH. 2021. Predicting the current and future potential spatial distribution of endangered *Rucervus eldii eldii* (Sangai) using Maxent model. Environ Monit Assess 193: 147. DOI: 10.1007/s10661-021-08950-1.

Araujo MB, Pearson RG, Thuiller W. 2005. Validation of species-climate impact models under climate change. Glob Change Biol 11: 1504-1513. DOI: 10.1111/j.1365-2486.2005.01000.x.

Austin MP. 2002. Spatial prediction of species distribution: an interface between ecological theory and statistical modeling. Ecol Modell 157 (1): 101-118. DOI: 10.1016/S0304-3800(02)00205-3.

Bakar MFA, Ahmad NE, Karim FA, Saib S. 2014. Phytochemicals and antioxidative properties of Borneo indigenous Liposu (*Baccaurea lanceolata*) and Tampoi (*Baccaurea macrocarpa*) fruits. Antioxidants 3: 516-525. DOI: 10.3390/antiox3030516.

Beck HE, Zimmermann NE, McVicar TR. Vergopolan N, Berg A, Wood EF. 2018. Data descriptor: Present and future Köppen-Geiger climate classification maps at 1-km resolution. Sci Data 5: 180214. DOI: 10.1038/sdata.2018.214.

Belgacem OA, Salem BH, Bouaicha A, El-Mourid M. 2008. Communal rangeland rest in arid area, a tool for facing animal feed cost and drought mitigation: the case of Chenini Community, Southern Tunisia. J Biol Sci 8 (4): 822-825. DOI: 10.3923/jbs.2008.822.825.

Belguidoum A, Lograda T, Ramdani M. 2021. Diversity and distribution of epiphytic lichens on *Cedrus antlantica* and *Quercus fagineain* mount Babor forest, Algeria. Biodiversitas 22 (2): 887-899. DOI: 10.13057/biodiv/d220244.

Benediktsson JA, Swain PH, Ersoy OK. 1993. Conjugate-gradient neural networks in classification of multisource and very-high-dimensional remote sensing data. Intl J Remote Sens 14: 2883-2903. DOI: 10.1080/01431169308904316.

Booth TH, Nix HA, Busby JR, Hutchinson MF. 2014. BIOCLIM: the first species distribution modelling package, its early applications and relevance to most current MAXENT studies. Divers Distrib 20: 1-9. DOI: 10.1111/ddi.12144.

Budiharta S, Widyatmoko D, Irawati, Wiriadinata H, Rugayah, Partomihardjo T, Ismail, Uji, T, Keim AP, Wilson K. 2011. The processes that threaten Indonesian plants. Oryx 45: 172-179. DOI: 10.1017/S0030605310001092.

Carpenter G, Gillison AN, Winter J. 1993. DOMAIN: a flexible modelling procedure for mapping potential distributions of plants and animals. Biodivers Conserv 2: 667-680. DOI: 10.1007/BF00051966.

Daşci M, Koc A, Comakli B, Gűllap MK, Cengiz MM, Erkovan HI. 2010. Importance of annual and seasonal precipitation variations for the sustainable use of rangelands in semiarid regions with high altitude. Afr J Agric Res 5 (16): 2184-2191. DOI: 10.5897/AJAR10.241.

Elith J, Phillips SJ, Hastie T, Dudík M, Chee Y, Yates CJ. 2011. A statistical explanation of maxent for ecologists. Diver Distrib 17 (1): 43-57. DOI: 10.1111/j.1472-4642.2010.00725.x

Fick SE, Hijmans RJ. 2017. Worldclim 2: New 1-km spatial resolution climate surfaces for global land areas. Intl J Clim 37(12): 4302-4315. DOI: 10.1002/joc.5086.

Fitriansyah SN, Putri YD, Haris M, Ferdiansyah R, Nurhayati R, Sari YP. 2018. Antibacterial activity of extracts of fruits, leaves, and barks of limpasu (*Baccaurea lanceolata* (Miq.) Müll.Arg.) from South Kalimantan. Pharmacy Jurnal Farmasi Indonesia 15: 2. DOI: 10.30595/pharmacy.v15i2.3062. [Indonesian]

Fitri A, Sudarman A, Yonekura L. 2016. Screening of antioxidant activities and their bioavailability of tropical fruit byproducts from Indonesia. Intl J Pharm Pharm Sci 8 (6): 96-100. DOI: 10.30595/pharmacy.v15i2.3062

Fois M, Cuena-Lombrana A, Fenu G, Bacchetta G. 2018. Using species distribution models at local scale to guide the search of poorly known species: Review, methodological issues and future directions. Ecol Model 385: 124-132. DOI: 10.1016/j.ecolmodel.2018.07.018.

Forman RTT. 1964. Growth under controlled conditions to explain the hierarchical distributions of a moss, *Tetraphis pellucida*. Ecol Monogr 34: 1-25. DOI: 10.2307/1948461.

Fourcade Y, Engler JO, Rodder D, Secondi J. 2014. Mapping species distribution with MaxEnt using geographically biased sample of presence data: a performance assesment of method for correcting sampling bias. PlosOne 9 (5): e97122. DOI: 10.1371/journal.pone.0097122.

Fyllas NM, Bentley LP, Shenkin A, Asner GP, Atkin OK, Díaz S, Enquist BJ, Farfan-Rios W, Gloor E, Guerrieri R, Huasco WH, Ishida Y, Martin RE, Meir P, Phillips O, Salinas N, Silman M, Weerasinghe LK, Zaragoza-Castells J, Malhi Y. 2017. Solar radiation and functional traits explain the decline of forest primary productivity along a tropical elevation gradient. Ecol Lett 20 (6): 730-740. DOI: 10.1111/ele.12771.

Galappathie S, Palombo E A, Yeo TC, Ley DLS, Tu CL, Malherbe FM, Mahon PJ. 2014. Comparative antimicrobial activity of South EastAsian plants used in Bornean folkloric medicine. J Herb Med 4: 96-105. DOI: 10.1016/j.hermed.2014.03.001.

Gebrewahid Y, Abrehe S, Meresa E, Eyasu G, Abay K, Gebreab G, Kidanemariam K, Adissu G, Abreha G, Darcha G. 2020. Current and future predicting potential areas of *Oxytenanthera abyssinica* (A. Richard) using MaxEnt model under climate cange in Northern Ethiopia. Ecol Proc 9: 6. DOI: 10.1186/s13717-019-0210-8.

Goyal AK, Mishra T, Sen A. 2014. Antioxidant profiling of Latkan (*Baccaurea ramiflora* Lour.) wine. Indian J Biotechnol 12 (1): 137-139.

Guisan A, Thuiller W, Zimmermann NE. 2017. Habitat Suitability and Distribution Models: With Application in R. Cambridge University Press. DOI: 10.1017/9781139028271.

Gunawan, Chikmawati T, Sobir, Sulistijorini. 2016. Review: Fitokimia genus *Baccaurea* spp. Bioeksperimen 2 (2): 96-106. DOI: 10.23917/bioeksperimen.v2i2.2488.[Indonesian]

Gunawan, Rizki MI, Anafarida O, Mahmudah N. 2021b. Modeling potential distribution of *Baccaurea macrocarpa* in South Kalimantan, Indonesia. Biodiversitas 22 (8): 3230-3236. DOI: 10.13057/biodiv/d220816.

Gunawan, Sulistijorini, Chikmawati T, Sobir. 2021a. Predicting suitable areas for *Baccaurea angulata* in Kalimantan, Indonesia using Maxent modelling. Biodiversitas 22 (5): 2646-2653. DOI: 10.13057/biodiv/d220523.

Haegens RMAP. 2000. Taxonomy, phylogeny, and biogeography of *Baccaurea, Distichirhops,* and *Nothobaccaurea* (Euphorbiaceae). Blumea 12 (1): 1-218.

Harapan TS, Nurainas, Syamsuardi, Taufiq A. 2022. Identifying the potential geographic distribution for *Castanopsis argentea* and *C. tungurrut* (Fagaceae) in the Sumatra conservation area network, Indonesia. Biodiversitas 23 (4): 1726-1733. DOI: 10.13057/biodiv/d230402.

Hemp A. 2006. Continuum or zonation? altitudinal gradients in the forest vegetation of Mt. Kilimanjaro. Plant Ecol 184: 27-42. DOI: 10.1007/s11258-005-9049-4.

Hijmans RJ, Graham CH. 2006. Testing the ability of climate envelope models to predict the effect of climate change on species distributions. Glob Change Biol 12: 2272-2281. DOI: 10.1111/j.1365-2486.2006.01256.x.

Hijmans RJ, Guarino L, Mathur P. 2012. DIVA-GIS version 7.5 Manual. https://www.diva-gis.org.

Hijmans RJ. 2020. Raster. Geographic data analysis and modeling. R package version 3.4-5. https://CRAN.R-project.org/package-raster.

Hilbish TJ, Branmock PM, Jones KR, Smith AB, Bullock BN, Wethey DS. 2010. Historical changes in the distribution of invasive and endemic marine invertebrates are contrary to global warming prediction: the effects of decadal climate oscillations. J Biogeogr 37: 423-431. DOI: 10.1111/j.1365-2699.2009.02218.x.

Hill MO, Preston CD. 2015. Disappearance of boreal plants in southern Britain: habitat loss or climate change ?. Biol J Linn Soc 115 (3): 598-610. DOI: 10.1111/bij.12500.

Hoveka LN, Bezeng BS, Yessoufou K, Boatwright JS, Van Der Bank M. 2016. Effects of climate change on the future distributions of the top five freshwater invasive plants in South Africa. S Afr J Bot 102: 33-38. DOI: 10.1016/j.sajb.2015.07.017.

IPCC. 2007. Contribution of working groups I, II, III, to the fourth assessment report of the intergovernmental panel on climate change. Climate Change 2007. Synthesis Report, Geneva.

Jackson CR. Robertson MP. 2011. Predicting the potential distribution of endengered cryptic subterranean mammal from few occurrence records. J Nat Conserv 19: 87-94. DOI: 10.1016/j.jnc.2010.06.006.

Ji W, Han K, Lu Y, Wei J. 2020. Predicting the potential distribution of the vine mealybug, *Planococcus ficus* under climate change by MaxEnt. Crop Prot 137: 105268. DOI: 10.1016/j.cropro.2020.105268.

Jordan GJ, Dillon RA, Weston PH. 2005. Solar radiation as a factor in the evolution of scleromorphic leaf anatomy in Proteaceae. Am J Bot 92 (5): 789-796. DOI: 10.3732/ajb.92.5.789.

Kaky E, Nolan V, Alatawi A, Gilbert F. 2020. A comparison between ensemble and MaxEnt species distribution modelling approaches for conservation: a case study with Egyptian medicinal plants. Ecol Inform 60: 101150. DOI: 10.1016/j.ecoinf.2020.101150.

Kalboussi M, Achour H. 2017. Modelling the spatial distribution of snake species in northwestern Tunisia using maximum entropy (MaxEnt) and geographic information system (GIS). J For Res 29: 233-245. DOI: 10.1007/s11676-017-0436-1.

Körner C. 2007. The use of altitude in ecological research. Trends Ecol Evol 22: 569-574. DOI: 10.1016/j.tree.2007.09.006.

Li Q, Lu H, Zhu L, Wu N, Wang J, Lu X. 2011. Pollen-inferred climate changes and vertical shifts of alpine vegetation belts on the northern slope Nyainqentanglha Mountains (central Tibetan plateau) since 8.4 kyr BP. Holocene 21 (6): 939-950. DOI: 10.1177/0959683611400218.

Lim TK. 2012. Edible Medicine and Non-Medicine Plants: Volume 4. Springer, London (GB). DOI: 10.1007/978-94-007-1764-0.

Martinez-Minajaya J, Cameletti M, Conesa D, Pennino MG. 2018. Species distribution modeling: A statistical review with focus in spatio-temporal issues. Stoch Environ Res Risk Asses 32: 3227-3244. DOI: 10.1007/s00477-018-1548-7.

Parmesan C. 2006. Ecological and evolutionary responses to recent climate change. Annu Rev Ecol Evol Syst 37: 367-669 DOI: 10.1146/annurev.ecolsys.37.091305.

Phillips SJ, Anderson RP, Dudik M, Schapire RE, Blair ME. 2017. Opening the black box: an open-source release of Maxent. Ecography 40: 887-893. DOI: 10.1111/ecog.03049.

Phillips SJ, Anderson RP, Schapire RE. 2006. Maximum entropy modeling of species geographic distributions. Ecol Model 190: 231-259. DOI: 10.1016/j.ecolmodel.2005.03.026.

Pradhan P. 2015. Potential distribution of *Monotropa uniflora* L. as a surrogate for range of Monotropoideae (Ericaceae) in South Asia. Biodiversitas 16 (2): 109-115. DOI: 10.13057/biodiv/d160201.

Pradhan P. 2016. Strengthening MaxEnt modelling through screening of redundant explanatory bioclimatic variables with variance inflation factor analysis. Researcher 8 (5): 29-34. DOI: 10.7537/marsrsj080516.05.

Pradhan P. 2019. Testing equivalency of interpolation derived bioclimatic variables with actual precipitation: A step towards selecting more realistic explanatory variables for species distribution modelling. Res J Chem Environ 23: 38-41.

Préau C, Isselin-Nondedeu F, Sellier Y, Bertrand R, Grandjean F. 2018. Predicting suitable habitat of four range margin amphibians under climate and land use changes in southwestern France. Reg Environ Chang 19: 27-38. DOI: 10.1007/s10113-018-1381-z.

Prodhan AHMSU, Mridu FS. 2021. *Baccaurea motleyana* (Rambai): nutritional, phytochemical, and medicinal overview. Adv Tradit Med. DOI: 10.1007/s13596-021-00555-w.

Rijksen HD. 1978. A field study on Sumatran Orang Utans (*Pongo pygmaeus abelii* Lesson 1827) ecology, behaviour and conservation. Communications Agricultural University Wageningen, Nederlands.

Romadlon MA, Az Zahra F, Nugroho GD, Pitoyo A. 2021. Population, habitat characteristic, and modelling of endangered orchid, *Paphiopedilum javanicum* in Mount Lawu, Java, Indonesia. Biodiversitas 22 (4): 1996-2004. DOI: 10.13057/biodiv/d220448.

Rugayah, Retnowati A, Windadri FI, Hidayat A. 2004. Pengumpulan Data Taksonomi. Puslit Biologi LIPI, Bogor. [Indonesian]

Setyawan AD, Supriatna J, Darnaedi D, Rokhmatuloh, Sutarno, Sugiyarto, Nursamsi I, Komala WR, Pradan P. 2017. Impact of climate change on potential distribution of xero-epiphytic selaginellas (*Selaginella involvens* and *S. repanda*) in Southeast Asia. Biodiversitas 18 (4): 1680-1695. DOI: 10.13057/biodiv/d180449.

Setyawan AD, Supriatna J, Nisyawati, Nursamsi I, Sutarno, Sugiyarto, Sunarto, Pradan P, Budiharta S, Pitoyo A, Suhardono S, Setyono P, Indrawan M. 2020a. Predicting potential impacts of climate change on the geographical distribution of mountainous selaginellas in Java, Indonesia. Biodiversitas 21 (10): 4866-4877. DOI: 10.13057/biodiv/d211053.

Setyawan AD, Supriatna J, Nisyawati, Nursamsi I, Sutarno, Sugiyarto, Sunarto, Pradan P, Budiharta S, Pitoyo A, Suhardono S, Setyono P, Indrawan M. 2020b. Anticipated climate changes reveal shifting in habitat suitability of high-altitude selaginellas in Java, Indonesia. Biodiversitas 21 (11): 5482-5497. DOI: 10.13057/biodiv/d211157.

Setyawan AD, Supriatna J, Nisyawati, Nursamsi I, Sutarno, Sugiyarto, Sunarto, Pradan P, Budiharta S, Pitoyo A, Suhardono S, Setyono P, Indrawan M. 2021. Projecting expansion range of *Selaginella zollingeriana* in the Indonesian archipelago under future climate conditions. Biodiversitas 22 (4): 2088-2103. DOI: 10.13057/biodiv/d220458.

Shao M, Wang L, Li B, Li S, Fan J, Li C. 2022. Maxent modeling for identifying the nature reserve of *Cistanche deserticola* Ma under effect of the host (*Haloxylon* Bunge) forest and climate changes in Xianjiang, China. Forest 13: 189. DOI: 10.3390/f13020189.

Song X, Milne RI, Fan X, Xie S, Zhang L, Zheng H, Fan L, Chung JM, Chung MG, Ma T, Xu X, Wang J, Mao K. 2020. Blow to the Northeast? Intraspecific differentiation of *Populus davidiana* suggest a north-eastward skew of phylogeographic break in East Asia. J Biogeogr 48: 187-201. DOI: 10.1111/jbi.13992.

Svenning JC, Sandel B. 2013. Disequilibrium vegetation dynamics under future climate change. Am J Bot 100. 1266-1286. DOI: 10.3732/ajb.1200469.

Swets JA. 1988. Measuring the accuracy of diagnostic system. Science 240: 1285-1293. DOI: 10.1126/science.3287615.

Thuiller W, Albert C, Araujo MB, Berry PM, Cabeza M, Guisan A, Hickler T, Midgley GF, Paterson J, Schurr FM, Sykes MT, Zimmermann NE. 2008. Predicting global change impacts on plant species distribution: Future challenges. Perspect Plant Ecol Evol Syst 9: 137-152. DOI: 10.1016/j.ppees.2007.09.004.

Ullah MO, Urmi KF, Howlader MDA, Hossain MDK, Ahmed MT, Hamid K. 2012. Hypoglycemic, hypolipidemic and antioxidant effects of leaves methanolic extract of *Baccaurea Ramiflora*. Intl J Pharm Sci 4 (3): 266-269.

Usha T, Middha SK, Bhattacharya M, Lokesh P, Goyal AK. 2014. Rosmarinic acid, a new polyphenol from *Baccaurea ramiflora* Lour. leaf: a probable compound for its anti-inflammatory activity. Antioxidants 3 (4): 830-842. DOI: 10.3390/antiox3040830.

Usmadi D, Sutomo, Iryadi R, Hanum SF, Darma I, Wibawa IPAH. 2021. Predicting species distribution for true indigo (*Indigofera tinctoria* L.) in Citarum Watershed, West Java, Indonesia. J Trop Biodivers Biotechnol 6 (3): 1-12. DOI: 10.22146/jtbb.65398.

Wei B, Wang R, Hou K, Wang X, Wu W. 2018. Predicting the current and future cultivation regions of *Carthamus tinctorius* L. using Maxent model under climate change in China. Glob Ecol Conserv 16: e00477. DOI: 10.1016/j.gecco.2018.e00477.

Worthington TA, Zhang T, Logue DR, Mittelstet AR, Brewer SK. 2016. Landscape and flow metrics affecting the distribution of a federally-threatened fish: improving management, model fit, and model transferability. Ecol Model 342: 1-18. DOI: 10.1016/j.ecolmodel.2016.09.016.

Yan H, Feng L, Zhao Y, Feng L, Di W, Zhu C. 2020. Prediction of the spatial distribution of *Alternanthera philoxeroides* in China based on ArcGis and MaxEnt. Global Ecol Conserv 21: e00856. DOI: 10.1016/j.gecco.2019.e00856.

Yang XQ, Kushwaha SPS, Saran S, Xu J, Roy PS. 2013. Maxent modeling for predicting the potential distribution of medicinal plant *Justicia adhatoda* L: in Lesser Himalayan foothills. Ecol Eng 51: 83-87. DOI: 10.1016/j.ecoleng.2012.12.004.

Yang ZX, Zhou GS, Yin XI, Jia RR. 2014. Geographic distribution of Laris gmelinii natural forest in China and its climatic suitability. Chin J Ecol 33: 1429-1436.

Yi YJ, Cheng X, Yang ZF, Zhang SH. 2016. Maxent modeling for predicting the potential distribution of endangered medicinal plant (*H. riparia* Lour) in Yunnan. China Ecol Eng 92: 260-269. DOI: 10.1016/j.ecoleng.2016.04.010.

Zamzani, Triadisti N. 2021. *Limpasu pericarpium*: An altenative source of antioxidant from Borneo with sequential maceration method. Jurnal Profesi Medika Jurnal Kedokteran dan Kesehatan 15 (1): 60-68. DOI: 10.33533/jpm.v15i1.2820. [Indonesian]

Zhang X, Li G, Du S. 2018. Simulating the potential distribution of *Elaeagnus angustifolia* L based on climatic constraints in China. Ecol Eng 113: 27-34. DOI: 10.1016/j.ecoleng.2018.01.009.

Zhang Y, Tang J, Ren G, Zhao K, Wang X. 2021. Global potential distribution prediction of *Xanthium italicum* based on Maxent model. Sci Rep 11: 16545. DOI: 10.1038/s41598-021-96041-z.

Predicting the current potential geographical distribution of Baccaurea (B. lanceolata and B. motleyana) in South Kalimantan, Indonesia

ORIGINALITY REPORT

14%	6%	12%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Dominik Fischer. "Combining Climatic Projections and Dispersal Ability: A Method for Estimating the Responses of Sandfly Vector Species to Climate Change", PLoS Neglected Tropical Diseases, 11/29/2011 Publication	1%
2	Gunawan, T Chikmawati, Sobir, Sulistijorini. " Distribution and Autecology of Belimbing Merah (Merr.) in Kalimantan ", IOP Conference Series: Earth and Environmental Science, 2018 Publication	1%
3	A. H. M. Safayet Ullah Prodhan, Farzana Sharmin Mridu. "Baccaurea motleyana (Rambai): nutritional, phytochemical, and medicinal overview", Advances in Traditional Medicine, 2021 Publication	1%

4	Maryam Farsi, Mansoor Kalantar, Mehrshad Zeinalabedini, Mohammad Reza Vazifeshenas. "First assessment of Iranian pomegranate germplasm using targeted metabolites and morphological traits to develop the core collection and modeling of the current and future spatial distribution under climate change conditions", Cold Spring Harbor Laboratory, 2022 Publication	1%
5	Chala Adugna Kufa, Afework Bekele, Anagaw Atickem. "Impacts of climate change on predicted habitat suitability and distribution of Djaffa Mountains Guereza (Colobus guereza gallarum, Neumann 1902) using MaxEnt algorithm in Eastern Ethiopian Highland", Global Ecology and Conservation, 2022 Publication	1%
6	b18d5336-fd16-4085-aab0-91c6e9386aae.filesusr.com Internet Source	1%
7	Fu Yanwen, Zhao Guojing, Dai Wenqian, Wang Yue et al. "Surprising leopard restoration in fragmented ecosystems reveals connections as the secret to conservation success", Science of The Total Environment, 2022 Publication	1%

8 Padalia, Hitendra, Vivek Srivastava, and S.P.S. Kushwaha. "Modeling potential invasion range of alien invasive species, Hyptis suaveolens (L.) Poit. in India: Comparison of MaxEnt and GARP", Ecological Informatics, 2014. <1%
Publication

---

9 Mario A. Carvajal, Alberto J. Alaniz, Ignacio Núñez-Hidalgo, Carlos González-Césped. " Spatial global assessment of the pest (Burmeister) (Heteroptera: Pentatomidae): current and future scenarios ", Pest Management Science, 2018 <1%
Publication

---

10 W K Michener, J W Brunt, S G Stafford. "Environmental Information Management And Analysis - Ecosystem To Global Scales", CRC Press, 2019 <1%
Publication

---

11 files.aiscience.org <1%
Internet Source

---

12 Cai, Xiaopeng. "Species distribution modeling for king mackerel (Scomberomorus cavalla) and its prey species in the Gulf of Mexico.", Texas A&M University - Corpus Christi, 2017 <1%
Publication

13	Wenguo Wang, Xiaoyu Tang, Qili Zhu, Ke Pan, Qichun Hu, Mingxiong He, Jiatang Li. "Predicting the Impacts of Climate Change on the Potential Distribution of Major Native Non-Food Bioenergy Plants in China", PLoS ONE, 2014 Publication	<1%
14	edepot.wur.nl Internet Source	<1%
15	iopscience.iop.org Internet Source	<1%
16	oeh-prod-cloudstorage.s3.ap-southeast-2.amazonaws.com Internet Source	<1%
17	spatial.usc.edu Internet Source	<1%
18	bonn.leibniz-lib.de Internet Source	<1%
19	scholarworks.umass.edu Internet Source	<1%
20	Submitted to CSU, San Marcos Student Paper	<1%
21	Submitted to Kookmin University Student Paper	<1%
22	Submitted to Medizinischen Universität Wien Student Paper	

<1%

23	Submitted to University of Leeds Student Paper	<1%
24	www.researcherslinks.com Internet Source	<1%
25	Jan Hjort, Miska Luoto. "Modelling patterned ground distribution in finnish lapland: an integration of topographical, ground and remote sensing information", Geografiska Annaler: Series A, Physical Geography, 2016 Publication	<1%
26	Jérémy Migliore, Alex Baumel, Agathe Leriche, Marianick Juin, Frédéric Médail. "Surviving glaciations in the Mediterranean region: an alternative to the long-term refugia hypothesis", Botanical Journal of the Linnean Society, 2018 Publication	<1%
27	Rattanawat Chaiyarat, Maneepailin Wettasin, Namphung Youngpoy, Navee Cheachean. "Use of Human Dominated Landscape as Connectivity Corridors among Fragmented Habitats for Wild Asian Elephants (Elephas maximus) in the Eastern Part of Thailand", Diversity, 2022 Publication	<1%

28	www.vliz.be Internet Source	<1%
29	M B C Mojulat, N Surugau. "A review on benefits, potential and conservation of Baccaurea lanceolata", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1%
30	Mahboubeh Sadat Hosseinzadeh, Mauro Fois, Bahman Zangi, Seyed Mahdi Kazemi. "Predicting past, current and future habitat suitability and geographic distribution of the Iranian endemic species Microgecko latifi (Sauria: Gekkonidae)", Journal of Arid Environments, 2020 Publication	<1%
31	Sugeng Budiharta, Didik Widyatmoko, Irawati, Harry Wiriadinata et al. "The processes that threaten Indonesian plants", Oryx, 2011 Publication	<1%
32	bioone.org Internet Source	<1%
33	core.ac.uk Internet Source	<1%
34	serval.unil.ch Internet Source	<1%

35	A. H. Hirzel, J. Hausser, D. Chessel, N. Perrin. "ECOLOGICAL-NICHE FACTOR ANALYSIS: HOW TO COMPUTE HABITAT-SUITABILITY MAPS WITHOUT ABSENCE DATA?", Ecology, 2002 Publication	<1 %
36	Alegria, Patrícia Aires. "Mudanças Climáticas e a Floração de Espécies Selecionadas de Plantas", Universidade de Aveiro (Portugal), 2023 Publication	<1 %
37	Emad Kaky, Victoria Nolan, Abdulaziz Alatawi, Francis Gilber. "A comparison between Ensemble and MaxEnt species distribution modelling approaches for conservation: A case study with Egyptian medicinal plants", Ecological Informatics, 2020 Publication	<1 %
38	Jason K. Blackburn. "Chapter 7 Integrating Geographic Information Systems and Ecological Niche Modeling into Disease Ecology: A Case Study of Bacillus anthracis in the United States and Mexico", Springer Science and Business Media LLC, 2010 Publication	<1 %
39	Rinkumoni Borah, Deepa Kumari, Anindita Gogoi, Sunayana Biswas, Ritusmita Goswami, Jaehong Shim, Naznin Ara Begum, Manish	<1 %

Kumar. "Efficacy and field applicability of Burmese grape leaf extract (BGLE) for cadmium removal: An implication of metal removal from natural water", Ecotoxicology and Environmental Safety, 2018
Publication

---

40 ouci.dntb.gov.ua <1%
Internet Source

---

41 Niane, Abdoul Aziz. "Impact of Grazing on Range Plant Community Components Under Arid Mediterranean Climate in Northern Syria.", Wageningen University and Research, 2020 <1%
Publication

---

42 C Moritz. "Identification and dynamics of a cryptic suture zone in tropical rainforest", Proceedings of The Royal Society B Biological Sciences, 01/06/2009 <1%
Publication

---

43 Erika Bazzato, Leonardo Rosati, Simona Canu, Michele Fiori, Emmanuele Farris, Michela Marignani. "High spatial resolution bioclimatic variables to support ecological modelling in a Mediterranean biodiversity hotspot", Ecological Modelling, 2020 <1%
Publication

---

44 Harald A. Mieg, Klaus Töpfer. "Institutional and Social Innovation for Sustainable Urban <1%

Development", Routledge, 2013
Publication

45	Hlavati-Širka, Vesna M.. "Rasprostranjenje, Ekologija i predviđanje Distribucije Invazivnih Taksona Roda Reynoutria Houtt. (Polygonaceae) Na području Srbije i jugoistočne Evrope", University of Belgrade (Serbia), 2023 Publication	<1 %
46	Tony Allan, Martin Keulertz, Suvi Sojamo, Jeroen Warner. "Handbook of Land and Water Grabs in Africa - Foreign direct investment and food and water security", Routledge, 2012 Publication	<1 %
47	Xingli Ma, Zhihong Li, Wenlong Ni, Weiwei Qu, Jiajiao Wu, Fanghao Wan, Xuenan Hu. "Chapter 30 The Current and Future Potential Geographical Distribution of the Solanum Fruit Fly, Bactrocera latifrons (Diptera: Tephritidae) in China", Springer Science and Business Media LLC, 2012 Publication	<1 %
48	it.wikipedia.org Internet Source	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		

Predicting the current potential geographical distribution of Baccaurea (B. lanceolata and B. motleyana) in South Kalimantan, Indonesia

GRADEMARK REPORT

FINAL GRADE

/100

GENERAL COMMENTS

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10