Media Konservasi Vol.28 No.2 Agustus 2023: 194-200
DOI: 10.29244/medkon.28.2.194-200 ISSN: 0215-1677
E-ISSN: 2502-6313

TYPOLOGY OF HABITAT NEPENTHES ARISTOLOCHIOIDES IN KERINCI SEBLAT NATIONAL PARK

BAKTI MANDALA[1*)], ERVIZAL A. M. ZUHUD[2)], AND DEDE AULIA RAHMAN[2)]

[1)]*Tropical Biodiversity Conservation Study Program, IPB, IPB Campus Dramaga, Bogor, 16680, Indonesia*
[2)]*Conservation of Forest and Ecotourism Department, Faculty of Forestry and Environment, IPB, IPB Campus Dramaga, Bogor, 16680, Indonesia*

**Email: bb.mandala@gmail.com*

Accepted June 25, 2021 / Approved June 08, 2023

ABSTRACT

Nepenthes aristolochioides is an endemic species found in Indonesia. This species has a narrow ecological distribution on Mount Tujuh, in the forest area of Kerinci Seblat National Park (TNKS), Kerinci Regency, Jambi Province. Nepenthes aristolochioides is a rare and critically endangered species of Nepenthes. Unfortunately, the study of environmental factors that influence its existence has not been widely studied. Therefore, a prediction model for the distribution of N.aristolochioides is needed as a solution for managing its habitat. This study aims to make a prediction map of the habitat of N.aristolochioides in Kerinci Seblat National Park. Characteristics of the environmental factors of the N.aristolochiodes habitat that play an essential role in habitat suitability are the variables BIO19 (Precipitation of Coldest Quarter), BIO1 (Annual Mean Temperature), BIO13 (Precipitation of Wettest Month), DEM (Digital Evaluation Model). Prediction of the distribution of N.aristolochiodes habitat with moderate habitat suitability of 10.523 ha, while with a high suitability level, is 4.176 ha. Habitats with a high level of conformity are spread over two main administrative areas, namely, Gunung Tujuh Sector, Gunung Kerinci Sector

Key words: *Habitat distribution, Maximum Entropy, Nepenthes aristolochioides*

INTRODUCTION

Pitcher plants have recently become a trend as commercial ornamental plants in Indonesia. In addition, the attractive colors and patterns of the pitcher make several types traded by the public as ornamental plants (Fadillah and Patana 2014). There are 80 species globally (Phillips 1996) and in 2001 increased to 87 species (Clarke 2001). There are now 139 species of these plants, with the majority of them living and growing in Indonesia, namely 68 species with 59 species with endemic status (Mansur 2013).

*Nepenthes aristolochioides*is one of 59 endemic species recorded in Indonesia. This species is found in a narrow distribution on Mount Tujuh located in the forest area of Kerinci Seblat National Park (TNKS), Kerinci Regency, Jambi Province. Clarke (2013) stated that *N.aristolochiodes* is a scarce and threatened species of Nepenthes. Five of the six subpopulations found are on steep mountain slopes, mossy and open areas. All subpopulation locations are areas that are very humid throughout the year. *N.aristolochiodes* generally live terrestrially but also found to live as an epiphyte in the forest (Clarke 2013). The small population size and limited distribution make *N.aristolochiodes* included in the Critically Endangered (CR) category based on the IUCN red list. Until now, not much research has been done or real conservation measures to protect *N.aristolochiodes* (Clarke 2013).

Spatial Distribution Modeling (SDM) is a model that measures the estimator variables (environmental factors) and the point of distribution of species (Elith and Leathwick 2009). SDM offers a quantitative approach to identify relationships between species and the environment that affect the geographic distribution of species (Elith and Leathwick 2009) . The basis of SDM lies in the use of presence and absence data obtained through observation, patient records, and literature. However, there are problems securing absence data in conducting observations, even when securing absence data cannot be relied upon because the amount is minimal (Yu *et al.* 2016). Spatial Distribution Modeling is expected to identify environmental factors that affect the distribution (Thorn *et al*. 2009).

According to Gray *et al.* (2017) pitcher plants species with a limited and small distribution have higher accuracy than pitcher plant species with broader distribution, making it easier to determine the habitats that are liked and disliked by the pitcher plant. Therefore, the habitat use prediction method is suitable for predicting the distribution and habitat of *N.aristolochiodes*. Conservation efforts are urgently needed to ensure the sustainability of this species.

Given the circumstances in which the number of populations continues to fall due to direct use and exploitation in the wild by decorative plant enthusiasts, it is impossible to ascertain the state of the population and environment (Barthlott *et al*. 2007). As a result, the goal of this research is to create a habitat distribution prediction map.

RESEARCH METHOD

This research was conducted from December 2018–February 2019 in the Kerinci Seblat National Park area in the Gunung Tujuh sector, Pelompek Village, Kerinci Regency, Jambi Province.

The tools used in this study were: a set of survey tools; GPS, ArcGis 10.5.1 used for spatial data processing, and MaxEnt ver 3.3.3k application used for modeling and analyzing environmental variables using the Maximum Entropy Method (Philips *et al.* 2018).

The data in this study comes from field observations of up to four presence points, as well as data from seven points of presence scattered throughout the Kerinci Seblat National Park in the Gunung Tujuh sector (Akhriadi *et al.* 2004).

Abiotic data are data on physical environmental elements that impact the condition of *N.aristolochiodes* habitat at the research site, particularly in the form of 19 variables from bioclimate, vegetation index (NDVI), humidity index (NDMI), elevation, slope, and surface temperature (Gray *et al*. 2017). All data is projected to WGS 1984 Zone 47 South, Gunung Kerinci District, Gunung Kerinci Regency, Jambi Province.

The selection of environmental variables depends on the availability of spatial data in the spatial modeling of the species because the availability of spatial data is a limiting factor in developing species distribution models (Osborne *et al.* 2001). Therefore, it is necessary to select environmental variables that affect the distribution of *N.aristolochiodes*.

Multicollinearity was corrected using the Pearson correlation coefficient (R2>0.7) for all variables used. So that the variables that are not positively or negatively correlated are obtained, namely, Bio1, Bio2, Bio3, Bio4, Bio13, Bio18, Bio19, DEM, Slope, Aspect, NDVI, and NDMI. Other environmental variables are eliminated and not used in the model to increase the accuracy of the model (Pearson *et al.* 2009).

This study uses Maxent v.3.3.3k with configuration using auto-feature. To achieve high accuracy, avoid over-predicting or inaccurate predictions, the number of iterations was increased to 5000 iterations from 500. We are using random seeds with a random test point of 25%. Replicate type is a subsample method using 11 replication (Philips *et al.* 2009).

RESULT AND DISCUSSION

1. ***Contribution of Environmental Variables***

Based on the analysis from MaxEnt, the environmental variable that affects the existence of *N.aristolochioides* is the BIO19 (Precipitation Of Coldest Quarter) variable with a contribution value of 38% in the prediction model with a permutation importance value of 68.6. Next is the variable BIO1 (*Annual Mean Temperature*), BIO13 (*Precipitation of Wettest Month*), DEM (*Digital Evaluation Model*), BIO18 (*Precipitation of Warmest Quarter*), and BIO2 (*Mean Diurnal Range*). Therefore, environmental variables that affect the presence of *N.aristolochiodes* can be seen in Table 1.

BIO19 is the most crucial variable in the presence of *N.aristolochiodes* , and provides information this species requires high rainfall in its habitat. The environmental variable BIO1 becomes the second most vital variable in the prediction model, accounting for 34% of the total. This variable includes the knowledge that ecological temperature is a critical factor in *N.aristolochiodes* environment. BIO13, the rainfall in the wettest months of the year, is the third most crucial variable. The habitat's elevation, precipitation during the dry season, and the variation in day and night temperatures are the following variables to consider. The results of the jackknife test show that environmental variables affect either individually or without variables. This test is carried out on the training data used to build the prediction model. The results of the jackknife test on the training data show that the environmental variables BIO1, BIO18, and DEM are the environmental variables that will give the highest value to the model. When just one variable is used in the prediction model of the *N.aristolochiodes* distribution, the three environmental factors become one influential variable. The results of the jackknife test on the training data can be seen in Figure 1.

Table 1 Environmental variables that affect the presence of *N.aristolochioides*.

Code Variable	Variable Environment	Percent Contribution	Permutation Importance
BIO19	Precipitation of Coldest Quarter	38	68,6
BIO1	Annual Mean Temperature	34,4	3,9
BIO13	Precipitation of Wettest Month	12,8	12,9
DEM	Digital Evaluation Model	7,7	12,9
BIO18	Precipitation of Warmest Quarter	3,7	0
BIO2	Mean Diurnal Range	2,5	1
BIO4	Temperature Seasonality	0,4	0,2
BIO3	Isothermality	0,1	0,1
Slope	Slope	0,1	0,1
Aspect	Slope Direction	0,1	0,2
NDVI	Normalize Difference Vegetation Index	0,1	0
NDMI	Normalize Difference Moisture Index	0	0

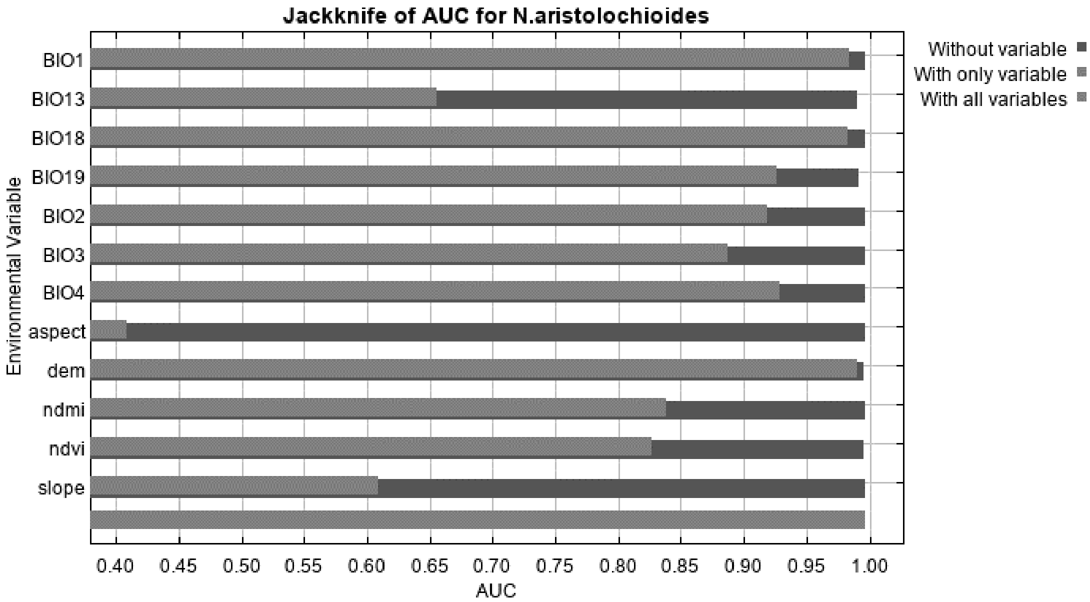

Figure 1 Jackknife test results from environmental variables

The results of the jackknife test in Figure 1 show that there is an aspect environment variable if it is ignored in the *N.aristolochiodes* distribution prediction model. However, it does not make the training gain value decrease significantly compared to the training gain value in the prediction model using all variables. This indicates that the environmental variable is not a variable that affects the prediction model for the distribution of *N.aristolochiodes* in Kerinci Seblat National Park

2. *Habitat Suitability Response Curve*

Variable response curves provide information about habitat characteristics that are close to the actual ecological state in nature. The relationship between the probability distribution of N.aristolochiodes with environmental variables can be seen in the response curve generated by the Maximum Entropy model. The response curve shows how highly variable ecological variables affect the prediction of the distribution of N.aristolochiodes in Kerinci Seblat National Park, as presented in the response curve of environmental variables. In addition, the response curve shows the quantitative relationship between environmental variables and the probability of presence (also known as habitat suitability). Thus, it deepens understanding of the ecological niche of the species (Yu et al. 2016). The probability distribution of N.aristolochioides on Bio1, Bio13, Bio19, and DEM can be seen in Figure 2.

The Bio1 variable is the annual average temperature recorded every month for one year. The response curve Bio1 variable shows the probability of the distribution of N.aristolochiodes is in the temperature range of 0-110oC. The Bio13 variable is the total precipitation in the month that has the highest rainfall throughout the year. The response curve of the Bio13 variable shows that the probability distribution of N.aristolochiodes is in the range of 260 to 300. The Bio19 variable is the total precipitation in three months that has the highest rainfall throughout the year. The response curve of the Bio19 variable shows that the probability distribution of N.aristolochiodes is in the range 740 to 1000. Finally, the DEM variable is the altitude above sea level where N.aristolochiodes lives.

3. ***Habitat Distribution Prediction Map***

Based on the value Area Under Curve (AUC), which represents the model performance, response curve, and analysis of the contribution of environmental variables to Maxent's prediction model, we can describe the prediction of the distribution of *N.aristolochiodes* in Kerinci Seblat National Park (Figure 3). The spatial model prediction of the distribution of *N.aristolochiodes* shows color gradations, where the color gradation has information about the prediction of the distribution of *N.aristolochiodes* in Kerinci Seblat National Park. The color gradation has a value range of 0-1, and it shows the probability distribution of *N.aristolochiodes* . The lower the prediction value, the lower the probability of the distribution of *N.aristolochiodes* in Kerinci Seblat National Park.

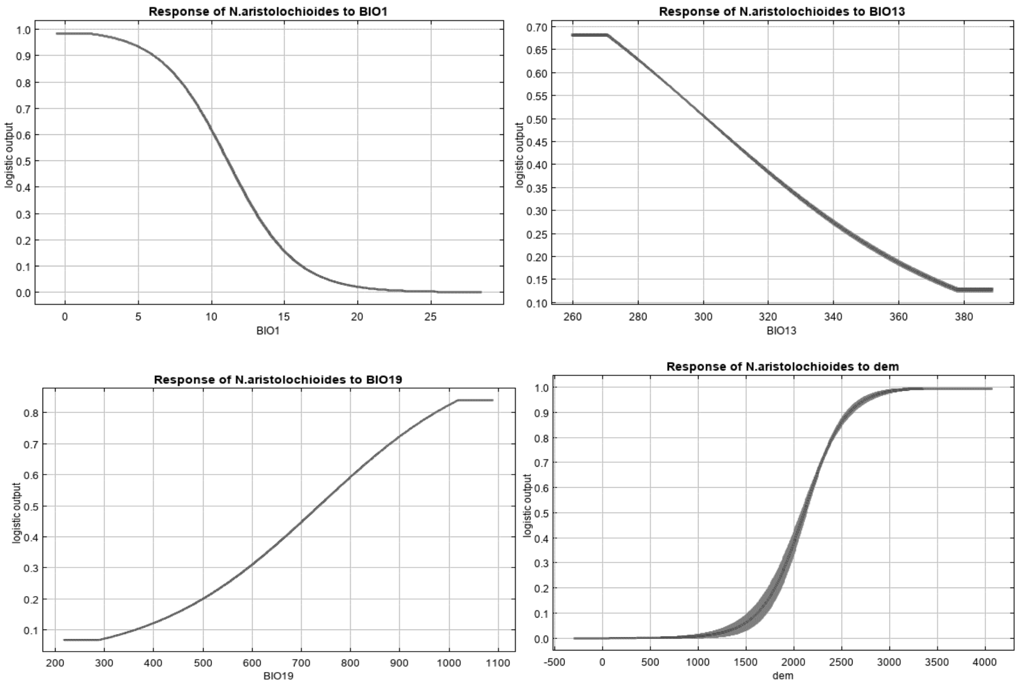

Figure 2 Probability distribution N.aristolochioides on the variables Bio1 (a), Bio13 (b), Bio19 (c) and DEM (d)

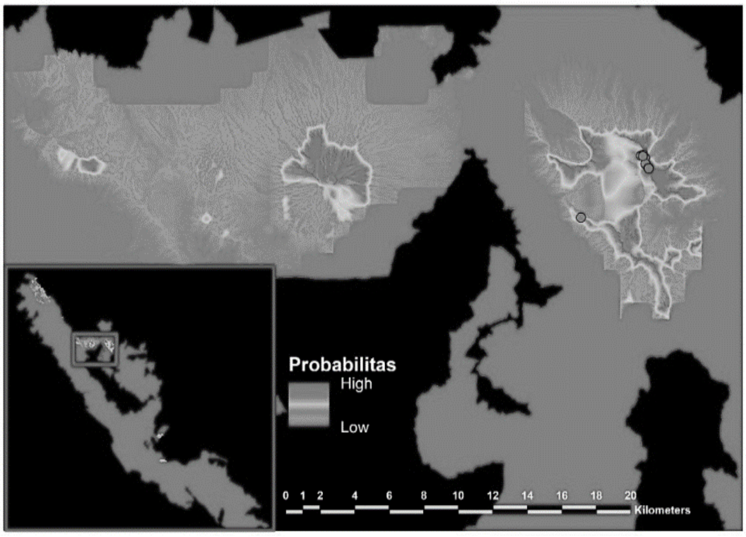

Figure 3 Map of distribution prediction results in N.aristolochioides based on environmental variables

Based on the prediction map for the distribution of N.aristolochioides, we can assume that the areas suitable for the growth of *N.aristolochiodes* are areas with the highest three-month precipitation value (BIO19) of low annual temperature (BIO1), and high one-month precipitation (BIO13).

The probability level of distribution of *N.aristolochiodes* is described by color gradation from blue with the lowest value to red with the highest value in the habitat suitability class. The probability level of the distribution of *N.aristolochiodes* is presented in Table 2.

Based on analysis of prediction map of the distribution *N.aristolochiodes* the low habitat suitability with score 0.1-0.4 predicted area of 26.375 ha or 1.9% from total area of Kerinci Seblat National Park, the moderate habitat suitability with score 0.4-0.6 predicted area of 5.882 or 0.4%, while highest opportunity value of with 0.6-1 predicted area of 4.176 ha or only 0.3% from total area Kerinci Seblat National Park.

High habitat suitability spread over three main administrative areas: Gunung Tujuh, Mount Kerinci, and Swamp behind Mount Kerinci. The results of the prediction of the distribution of *N.aristolochiodes* based on habitat suitability can be seen in Figure 4. These locations have high precipitation based on the value of BIO19, and This is supported by the fact that *N.aristolochiodes* requires high rainfall and high humidity (Clarke 2013).

4. Model Evaluation

The performance and evaluation of the Maxent model in predicting the distribution of *N.aristolochioides* in Kerinci Seblat National Park can be seen from the Receiver operating characteristic (ROC) curve, which is one of the outputs of this model. The results of the model evaluation are illustrated by the sensitivity and 1-specificity graphs. The review of the model in this study showed that the probability of the presence of *N.aristolochiodes* in Kerinci Seblat National Park resulted in an excellent performance. According to Swets (1988), the model's performance is indicated by the high Area Under Curve (AUC) value. The model's performance is divided into several classes, with a value of 0.6-0.7 considered low, 0.7-0.8 considered moderate, 0.8-0.9 considered good, and more than 0.9 indicating a high level of accuracy in measuring the resulting model with the presence data. The AUC value for the probability distribution model of N.aristolochioides in this study shows a high level of performance that is 0.996 (Figure 5).

Using a small amount of presence data to build a model can result in biased prediction results, but according to Gray *et al.* (2017), pitcher plants species that live in the mountains and have a narrow distribution area have a higher model accuracy than the Pitcher plant species with a broader distribution. So that the *N.aristolochiodes* species has a small amount of presence data because it lives in mountainous areas, it has a higher model accuracy.

According to the prediction model results, the Mount Kerinci area has a very high predictive value for the distribution probability of *N.aristolochiodes*, namely 0.75-1. This proves that according to Clarke (2001), *N.aristolochioides* was first collected by Robinson and Kloss with the label "Mt. Kerinci" herbarium collection. This can prove that the model's performance has high accuracy and shows a pretty good level of model accuracy. However, according to Hernawati (2004) currently around the Mount Kerinci area, the population of *N.aristolochiodes* is no longer found

Table 2 Habitat suitability level of *N.aristolochioides*

Conformity Level	Score	Area (ha)	Area Percentage
Low habitat suitability	0,1 – 0,4	26,375	1,9 %
Medium habitat suitability	0,4 – 0,6	5,882	0,4%
High habitat suitability	0,6 – 1	4,176	0,3%
The total area of Kerinci Seblat National Park		1,371,509	100%

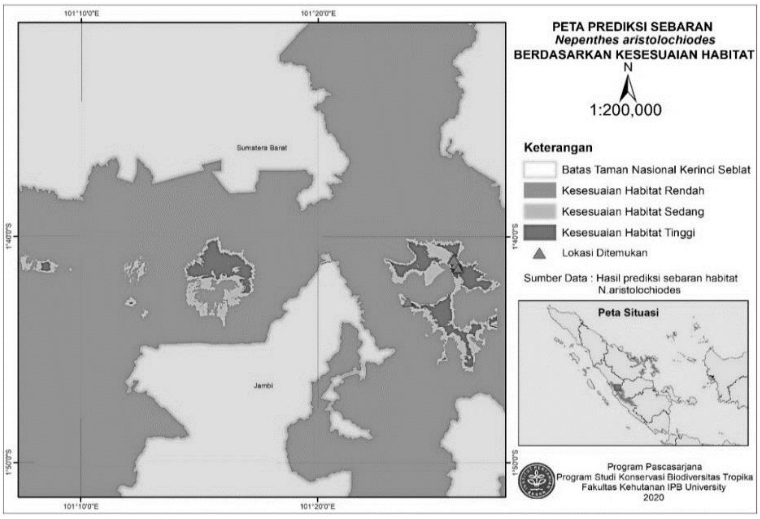

Figure 4 Prediction Map of Nepenthes aristolochioides *distribution based on habitat suitability*

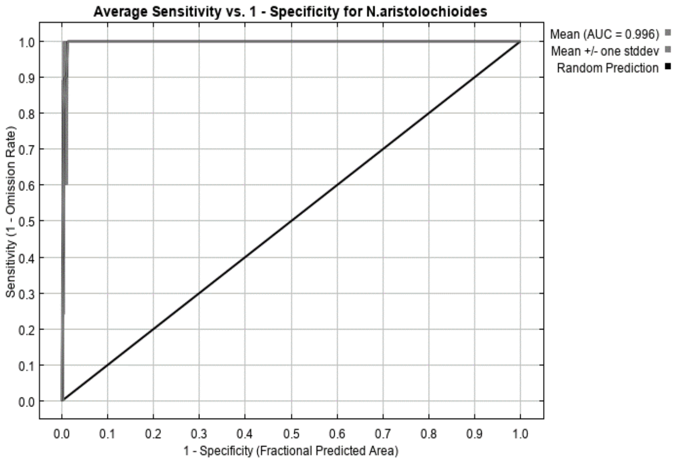

Figure 5 Maxent model performance in predicting the distribution of N.aristolochioides *in Kerinci Seblat. National Park*

CONCLUSION

Based on results the analysis, the variables that most influence the prediction model is precipitation of coldest quarter (BIO19). This proves that *Nepenthes aristolochioides* require specific environmental conditions to survive in nature within small area that provide this condition makes *N.aristolochiodes* endemic and has small distribution.

Based on the prediction of the distribution of *Nepenthes aristolochioides* by adjusting the habitat, the area is 4.176 ha or 0.3% of the size of Kerinci Seblat National Park. Therefore, the population distribution of Nepenthes aristolochioides which is small and continues to decline every year requires serious conservation action, especially from the management of the national park. In short, the condition of the Nepenthes aristolochioides population will be worrying because of its predicted small and fragmented habitat distribution in two areas, namely the Gunung Tujuh sector and the Gunung Kerinci sector in the Kerinci Seblat National Park

REFERENCES

Akhriadi P, Hernawati, Tamin R. 2004. A new species of Nepenthes (Nepenthaceae) from Sumatra. *Journal Reinwardtia*.12 (2): 141 – 144.

Barthlott W, Porembski S, Seine R, Theisen I. 2007. The Curious World of Carnivorous Plants. Oregon (OR). Timber Press.

Clarke CM. 2001. *Nepenthes of Sumatra and Peninsular Malaysia*. Malaysia (MY). Natural History Publications.

Clarke CM. 2013. N*epenthes aristolochioides; The IUCN Red List of Threatened Species 2013*. e.T39644A19630981. http://dx.doi.org/10.2305/IUCN. UK.2013-2.RLTS. T39644A19630981.en

Elith J, Leathwick JR. 2009. Species distribution models: Ecological explanation and prediction across space and time. *Journal Annual Review of Ecology, Evolution, and Systematics*. 40: 677–697. Doi: 10.1146/annurev.ecolsys.110308.120159.

Fadillah N, Patana P. 2014. Diversity of nepenthes on Kebun Bonsai and the surrounding areas in dolok sibual buali nature reserve, North Sumatra. *Journal Peronema Forestry Science*. 3(2): 1-9.

Gray LK, Charles C, William WGR, Moran JA. 2017. Potential effects of climate change on members of the Palaeotropical pitcher plant family Nepenthaceae. *Journal Plos One*. 12(8):1-17. Doi: 10.1371/journal.pone.0183132.

Hernawati. 2004. Nepenthes *Project 2002 A Conservation Expedition of Nepenthes in Sumatra Island* : Final Report January 2004. Sumatera Barat. Indonesia.

Mansur M. 2013. Tinjauan tentang nepenthes (nepenthaceae) in Indonesia [a review of nepenthes (nepenthaceae) in Indonesia], *Berita Biologi*. 12(1), pp. 1–7.

Osborne PE, Alonso JC, Bryant RG. 2001. Modelling landscape scale habitat use using GIS and remote sensing: A case study with great bustards', *Journal of Applied Ecology*. 38 (2): 458–471. Doi: 10.1046/j.1365-2664.2001.00604.x.

Pearson RG, Raxworthy CJ, Nakamura M, Townsend PA. 2007. Predicting species distributions from small numbers of occurrence records : a test caseusing cryptic geckosin Madagascar. *Journal Biogeog*. 34:102–117.

Phillips A. 1996. *Pitcher Plants of Borneo*. Kinabalu (MY). Natural History Publicationsr.

Phillips SJ, Dudik M, Schapire RE. 2018. Maxent Software for modelling species niches and distribution (Version 3.4.1). Available from url: http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2018-6-30

Swets JA. 1988. Measuring the accuracy of diagnostic systems. *Journal Science*. 240 (4857): 1285–1293. Doi: 10.1126/science.3287615.

Yu JY, Xi C, Zhi FY, Shang HZ. 2016. ‘Maxent modeling for predicting the potential distribution of endangered medicinal plant (H. riparia Lour) in Yunnan, China. *Journal Ecological Engineering*. 92. 260–269. Doi: 10.1016/j.ecoleng.2016.04.010.