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PREDICTING POTENTIAL HABITAT DISTRIBUTION OF *HABENARIA LONGICORNICULATA* J. GRAHAM IN WESTERN GHATS, INDIA

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Abstract

The population of the medicinal plant, *Habenaria longicorniculata* J.Graham is shrinking due to habitat degradation and its over-exploitation. Predicting potential geographic distribution of the species is important for conservation of a species and restoration of its habitat. The present study was carried out to predict the current and future suitable distribution of *H. longicorniculata* in India using Maxent species distribution model; 20,928 km^2 of the total predicted area was found to be most suitable. Precipitation of the wettest month (Bio 13), precipitation of driest month (Bio 14) and isothermality (Bio 3) were the strongest predictors for the distribution of *H. longicorniculata* with 68% and 6.9% respectively. The model results suggest significant probable decrease of highly suitable habitat of 17% area, in future. Therefore, proper conservation planning is needed for *H. longicorniculata*. The Maxent model used in this study can be used to forecast the distribution of the species and may be helpful for its rehabilitation and improving conservation status.

Introduction

HABENARIA WILLD. (Orchidaceae) is a large genus consisting of approximately 883 terrestrial species (Govaerts *et al.,* 2018) distributed throughout tropical and subtropical regions of the world (Pridgeon *et al.*, 2001), with centers of diversity in Brazil, Southern and Central Africa, and East Asia (Batista *et al.,* 2013; Kurzweil and Weber, 1992). There are 69 species in India and 39 of them are reported in Western Ghats, with 22 being endemic (Kumar *et al.,* 2016; Nayar *et al.*, 2014).

Habenaria longicorniculata J. Graham is a terrestrial herb having sub-globose tubers with several slender roots. It has its typical habitat in rocky and gravelly area and undergrowth in forest areas (Purohit *et al.*, 2020). The tubers are edible and have medicinal properties (Purohit *et al.*, 2020). The tuber paste with turmeric is applied externally for leucoderma (Roy *et al.*, 2007). The populations of *H. longicorniculata* are shrinking and the major threat of their decline is due to consumption of tubers by wild animals, over-exploitation for its commercial uses, habitat degradation and fragmentation, and other developmental activities (Purohit *et al.*, 2020). The present study was carried out to predict the current and future suitable distribution of medicinally important, *H. longicorniculata* in India using Maxent species distribution model; the method may be helpful for its rehabilitation and improving conservation status.

Material and Methods

Primary occurrence data for model building and evaluation were obtained from the web resource of Global Biodiversity Information Facility (http://www.gbif.org) and through field surveys in different parts of India. The coordinates of all the occurrence points obtained through field surveys were recorded to an accuracy of 3-10 m using GPS (Garmin). These coordinates were then converted to decimal degrees for use in modeling the distribution of habitats of the species. Secondary occurrence data were obtained through published literature (Li *et al.*, 2011). To avoid spatial autocorrelations, only one location per grid was used in modeling. Finally, a total of 48 occurrence points of *H. longicorniculata* were identified and included in this study to model current and future potential distribution of the species. Bioclimatic variables (Hijmans *et al.*, 2005) with 30 seconds spatial resolution, downloaded from WorldClim dataset (www.worldclim.org) were used in the present study. These WorldClim data (period 1950-2000) are derived from measurements of altitude, temperature and rainfall from weather stations across the globe and are frequently used in modeling species distribution (Adhikari *et al.*, 2012; Khanum *et al.*, 2013; Kumar and Stoghlgren, 2009; Sanchez *et al.*, 2011).

For habitat modeling, the model was developed using Maximum entropy distribution software (Maxent version 3.3.3; Phillips *et al.*, 2006; http://www.cs.princeton.edu/wschapire), which generates an

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estimate of probability of the presence of species that varies from 0 to 1, where 0 is the lowest and 1 is the highest probability. Of the 48 records, seventy five per cent were used for model training and twenty five per cent for testing. To validate the model robustness, 10 replicated models runs for the species with a threshold rule of 10 percentile training presence was executed. In the replicated runs, cross validation technique was employed, where samples were divided into replicate folds and each fold was used for test data. Other parameters were set to default as the programme is already calibrated on a wide range of species datasets (Phillips and Dudík, 2008). From the replicated runs average, maximum, minimum, median and standard deviation were generated. Jackknife procedure and per cent variable contributions were used to estimate the relative influence of different predictor variables. Receiver operating characteristics (ROC) analyse the performance of a model at all possible threshold by a single number called, the area under the curve (AUC). AUC is a measure of model performance and varies from 0 to 1 (Fielding and Bell, 1997). Higher AUC values correspond to better model quality and accuracy. The Area under the ROC curve was used to evaluate model performance. Future climate scenario data for 2050 (A2a emission scenario) were obtained from Consultative Group on International Agricultural Research (CGIAR) (http://ccafsclimate.org). These future climate projections are based on IPCC 4th assessment data and were calibrated and statistically downscaled using the data for current conditions.

Results

An AUC value of 0.50 indicates that model did not perform better than random whereas a value of 1.0 indicates perfect discrimination (Swets, 1988). The Maxent model for *Habenaria longicorniculata* performed well with an average AUC value of 0.977 (Fig. 1). To minimize the possible errors in species occurrence data, duplicate records were eliminated. Most suitable habitat was predicted in Western Ghats (Fig. 2a,b) with an area of 20,928 km^2 (Fig. 3a) of high suitability. Table 1 shows the relative contributions of the predictor variables in Maxent for distribution of *H. longicorniculata*. Precipitation of the wettest month (Bio 13), precipitation of driest month (Bio 14), isothermality (Bio 3), and temperature seasonality (Bio 4) were the strongest predictors for the distribution *H. longicorniculata* with 68%, 6.9%, 6.6%, and 6.6% contributions, respectively. The probability of presence of *H. longicorniculata*

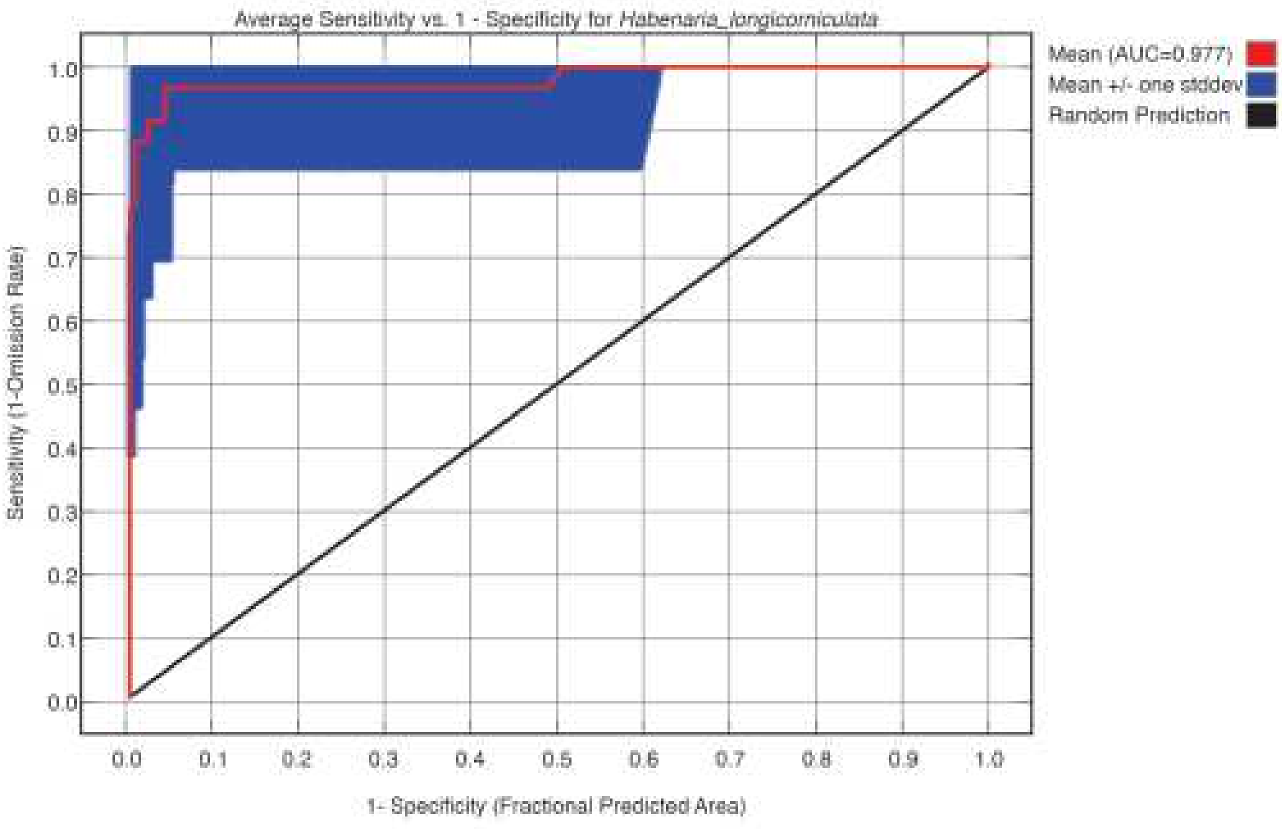

Fig. 1. Result of AUC in developing habitat suitability model for *Habenaria longicorniculata*.

Table 1. Selected environmental variables and their per cent contribution in Maxent model for *Habenaria longicorniculata*.

Environment Variables	Per cent Contribution
Precipitation of wettest month (Bio 13)	68
Precipitation of driest month (Bio 14)	6.9
Isothermality (Bio 3)	6.6
Temperature seasonality (Bio 4)	6.6
Mean temperature of coldest quarter (Bio 11)	4.3
Precipitation of warmest quarter (Bio 18)	2.7
Mean temperature of wettest quarter (Bio 8)	2.1
Precipitation of driest quarter (Bio 17)	2
Min temperature of coldest month (Bio 6)	0.6
Mean temperature of driest quarter (Bio 9)	0.2

increased with an increase in precipitation of wettest month (Fig. 4). Relative importance of different environmental variables based on results of jackknife tests in Maxent are shown (Fig. 5).

Compared with the area of most suitable habitat (20,928 km^2) under current climate prediction, the future prediction model for 2050 (A2a emission scenario) showed decrease of habitat (Fig. 2b), with the most optimal geographic distribution of 17,339 km^2 (Fig. 3b). Although the location of future potential distribution of *H. longicorniculata* is very similar to the current potential distribution, the model results suggest a significant probable decrease of highly suitable habitat of 17% area.

Discussion

The present results indicate that precipitation of the wettest and driest month is the major factor which primordially influences the growth of *H. longicorniculata*. The other factors which influence the prevalence of *H. longicorniculata* in the new areas are isothermality and temperature seasonality. The present study also indicates that there is a probability of decrease in suitable habitat for *H. longicorniculata,* in 2050. The zone mapped in the study with higher model thresholds suggests that these areas have ideal habitat conditions for *H. longicorniculata*. There is a possibility that many areas predicted to have suitable habitat for the species be devoid of populations due to its over collections for medicinal purposes and increased anthropogenic activities in the areas of their occurrence which might result in considerable depletion of its natural populations. Therefore, conservation planning is immediately needed. Multiple strategies including *in situ* conservation in protected areas with suitable habitats and *ex situ* conservation should be implemented so as to preserve *H. longicorniculata*. Macro- and micro-propagation of these plants can be done in controlled conditions and these plantlets can be introduced to the suitable protected sites, identified through the ecological niche modeling.

The present study highlights the ecological parameters visualized through Ecological Niche Modeling (ENM) techniques, and will contribute to the basic ecological needs required for reintroduction of the species. ENM

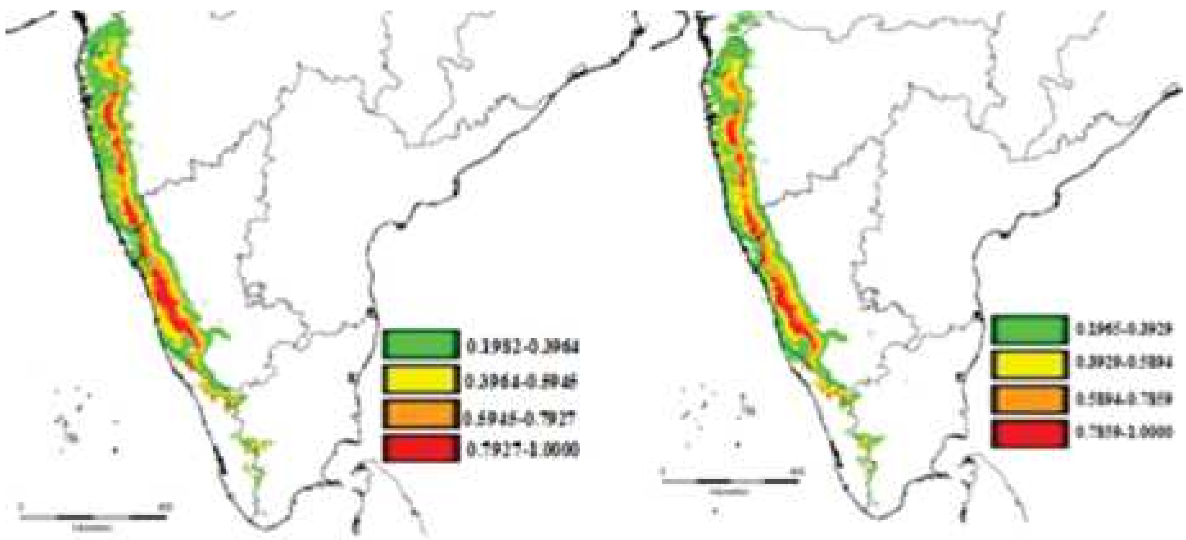

Fig. 2. a, Predicted current potential suitable habitat of *Habenaria longicorniculata*; b, Predicted future potential suitable habitat of *Habenaria longicorniculata* [Shapefile republished from DIVA-GIS database (https:// www.diva-gis.org/) under a CC BY license, with permission from Global Administrative Areas (GADM), original copyright 2018].

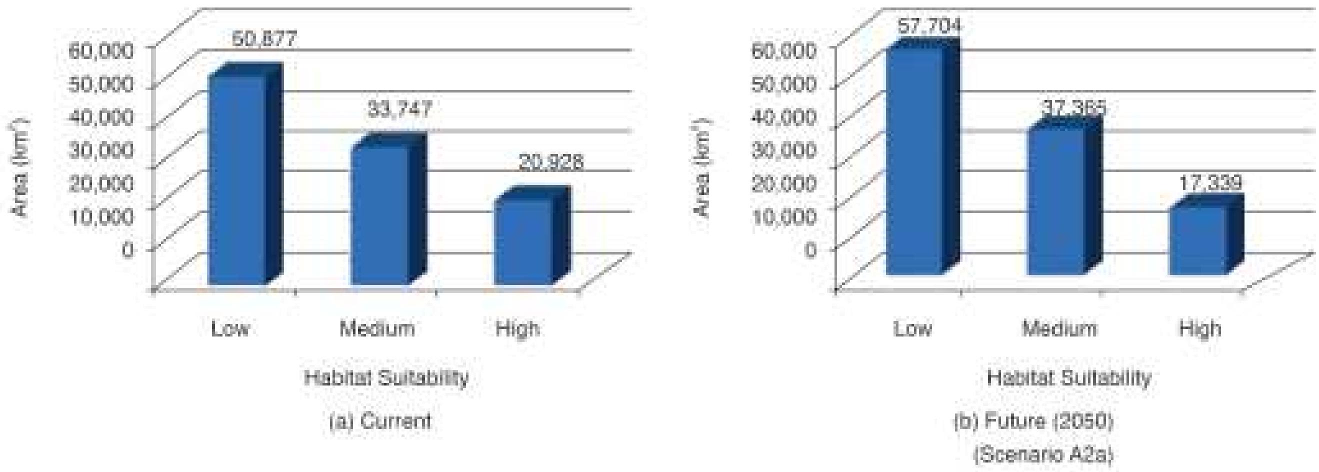

Fig. 3. Area under different suitable habitats; the figures at the top of each bar represent the area.

helps in categorization of species under different threat classes and is a pre-requisite for planning, management, and monitoring for conservation programme of any species. However, data availability, particularly at the population level, has been a major bottleneck in the correct categorization of threatened species (Adhikari *et al.*, 2018). Ecological niche Modeling can play an important role in various *in situ* and *ex situ* conservation measures for establishment of arboreta, sanctuaries, parks and reserve forests, protected areas through community management, botanical gardens, and also for *in vitro* research activities for species conservation (Menon *et al.*, 2012). The method is certainly promising in predicting the

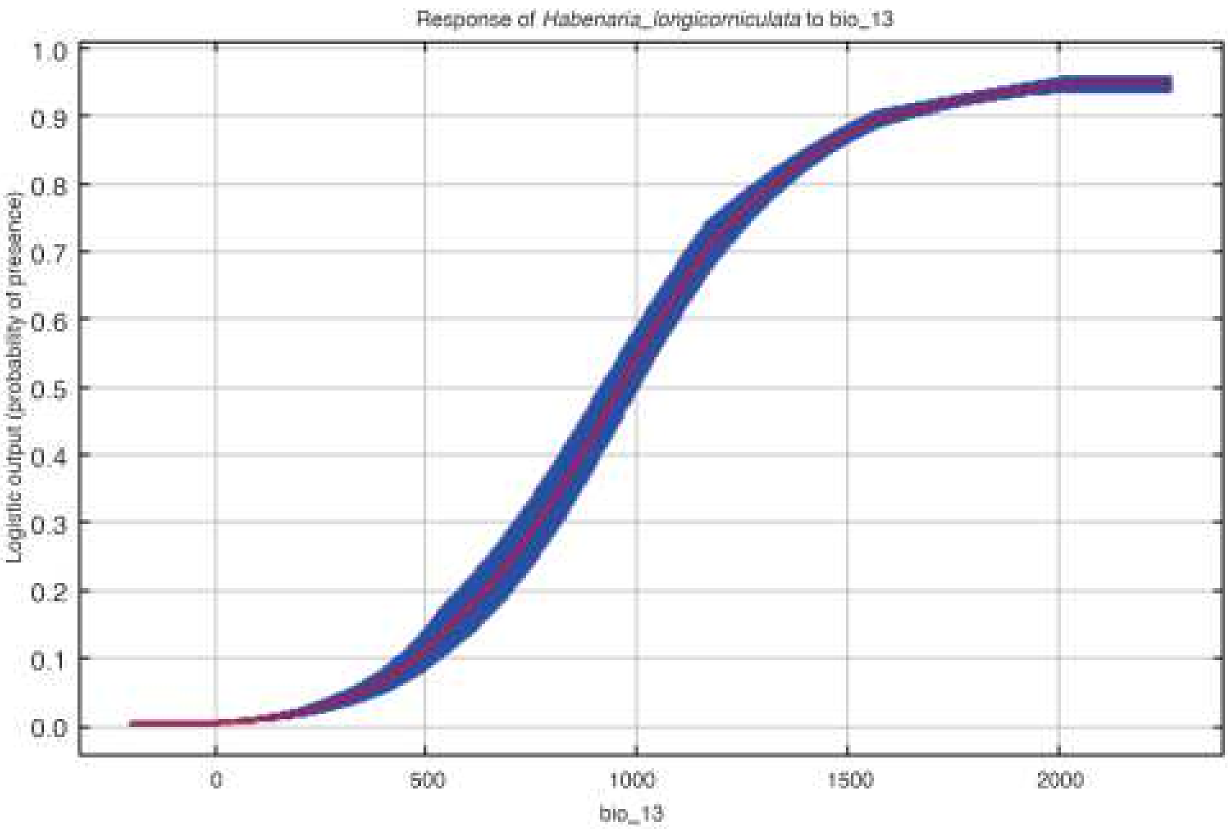

Fig. 4. Response curves showing relationships between probability of presence of a species and top bioclimatic predictor (precipitation of wettest month) of *Habenaria longicorniculata*.

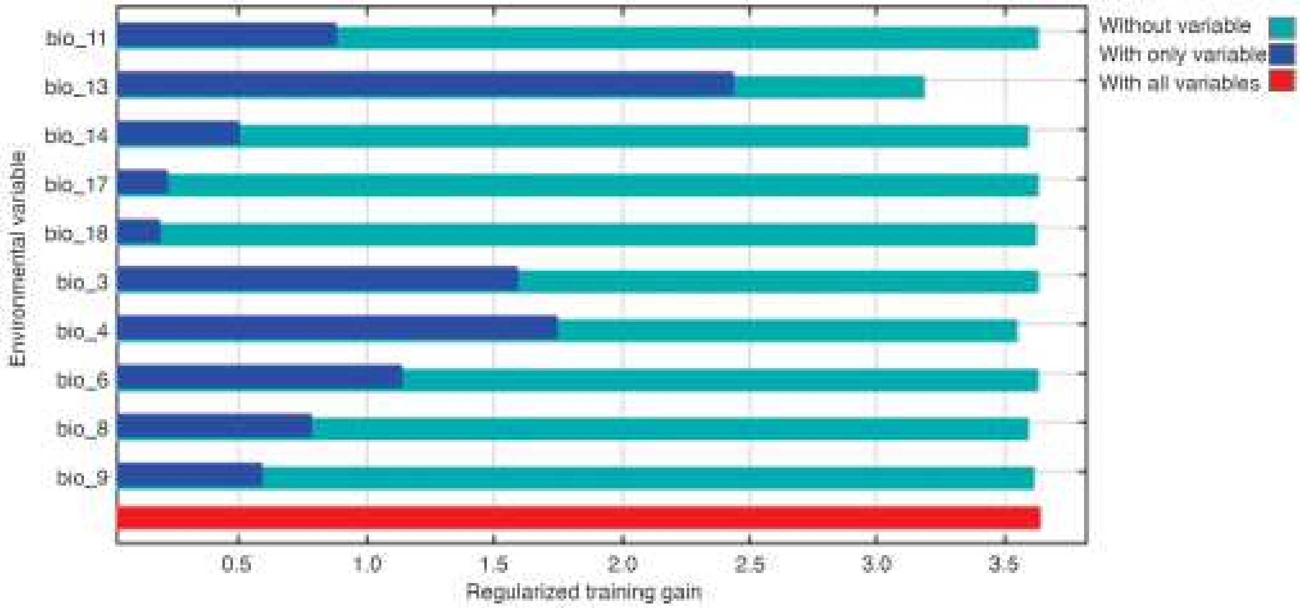

Fig. 5. Relative predictive power of different bioclimatic variables based on the jackknife of regularized training gain in Maxent model for *Habenaria longicorniculata*.

potential distribution of other endangered species and further prove as a valuable tool in species distribution studies and conservation planning. The areas predicted in the present study can help in rehabilitation of *H. longicorniculata* and improving its conservation status. The current and predicted map of suitable habitat and identification of suitable bioclimatic variables can be of significant use for government and non-government organizations responsible for management and conservation of threatened medicinal plants (Malay *et al.*, 2018; Sourabh *et al.*, 2018).

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