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Potential Geography and Conservation of *Ipomoea beninensis*, an Endangered Plant Species for Benin (West Africa) †

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Abstract: The endemic plant of Benin, *Ipomoea beninensis* Akoègn, Lisowski and Sinsin, is threatened in its natural habitats. This study assesses the suitability of the current and future habitat for its conservation countrywide. Maxent models were run using records added to environmental variables under present and two climates. The results showed that the most suitable areas for *I. beninensis* will be mainly in the phytodistrict of southern and northern Borgou. The species could lose 9% and 13.6% of its suitable habitats under RCP4.5 and RCP8.5, respectively. Urgent and timely strategies are needed to save the remaining population of the species.

Keywords: conservation; climate changes; threatened taxa; West Africa

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1. Introduction

Worldwide, the biological diversity is evolving in an environment that is changing at an unstoppable and disturbing pace [1]. The world is undergoing significant lifestyle change, closely linked to both natural phenomena and anthropogenic factors [2]. In the natural ecosystems, the function and structure have been affected by human activities and climate changes, the impacts of which will worsen in the near future [3]. As a result, the world is expected to experience an unexpected vulnerability of all features of biodiversity, climate systems, and the people who depend on them for their daily needs.

Nonetheless, there is increasing evidence that climate variables, such as precipitation and temperature, will affect the biological biodiversity and the geographic distribution of suitable habitats for species [4]. *Ipomoea beninensis* Akoegninou, Lisowski and Sinsin is an endemic plant (Convolvulaceae), which was first described in Benin in 1999 [5]. It grows in forests and wooded savannas in the Guineo-Sudanese and Sudanese zones in Benin [5]. It plays an important role in meeting the needs of local populations, especially in rural areas, whether environmental, social, or cultural, with its rhizome being used to treat chickenpox and malaria as fodder [6]. For some years, its populations have also been exposed to bushfires that affect the availability of its above-ground parts, justifying its poor management and leading to its rapid decline in natural habitats [6]. To better understand the very poorly known distribution of the species and improve its monitoring in biodiversity monitoring campaigns, this study assessed the current distribution of *Ipomoea beninensis*, and projected its future distribution under climate scenarios.

2. Materials and Methods

2.1. Study Area

The study was conducted in the two ecological zones of the Guinea-Sudanese transition area (7°30′ N to 9°45′ N) and the Sudanese area (9°45′ N to 12°25′ N) in Benin.

2.2. Occurrence Data

In whole, 189 occurrence records were gathered from the field, and supplemented by those (69) downloaded from online resources (GBIF: http://www.gbif.org, (21 September 2019), https://doi.org/10.15468/dl.5rnzkg). Data were quality checked [7]. In addition, we discarded duplicate records and those with obvious errors.

2.3. Environmental Variables

In this study, 21 bioclimatic variables were downloaded (≈1 km) from the Africlim website (www.africlim.org, accessed on 1 March 2021) for both baseline and future climates. For future climate projections, the Ensemble model [8] was used, and the projections were made for 2055 under RCP 4.5 and 8.5 scenario. In addition, soil layers were obtained at the same resolution from (https://databasin.org, accessed on 1 March 2021) and from Africa Soil Profiles Database (https://www.isric.org, accessed on 1 March 2021), respectively. We discarded highly correlated variables ($\geq$0.8) by using Pearson´s rank correlation coefficients and converted to Ascii format.

2.4. Species Distribution Models' Development

The Maximum Entropy modelling approach, MaxEnt version 3.4.4k [8] was used to map the present-day and future distribution of *I. beninensis*. Linear, quadratic, product, hinge, and threshold functions of predictor variables were checked, and variable importance was assessed using a jackknife analysis [9]. We restricted the selection of background points using the regularisation of 10,000 background points. To ease the interpretation of the findings, we specified the Maxent' output format to a logistic form. All models were run ten (10) times. We computed the performance of the models using the area under the receiver operating characteristics curve (AUC) and the partial receiver operator characteristics (pROC) [10]. The dynamic of these patterns of suitability classes were quantified.

3. Results

3.1. Variables' Contribution and Models Performance

The 10-time replications highlighted five (05) variables as most contributing to the distribution of *I. beninensis*: mean diurnal range in temperature, Temperature seasonality, mean temperature of warmest quarter, rainfall of the wettest month, and elevation. Overall, variables related to temperature were more represented in the selection. The performance of the models assessed through AUC and partial ROC revealed a value of AUC of 0.84 and a value of AUC ratio was 1.6, thus indicating that our models have very good predictive power.

3.2. Current and Future Distribution of I. beninensis across Benin

The models showed under the present condition (Figure 1) that the highly suitable habitat for *I. beninensis* were mainly located in the phytodistricts of Borgou (south and north). However, the phytodistrict of Bassila as well as the Atacora chain phytodistrict were found to be favourable for the conservation of the species. The moderately suitable habitats were located in the same phytodistricts abovementioned. Analyses based on projecting the final models into the future (by 2055) scenarios revealed that (Figure 1) the highly suitable habitats for the species will be more concentrated in the phytodistricts of Borgou (south and north) for both scenarios. In addition, part of the highly suitable area will remain alongside the East sides of the study area. Assessment of the dynamics of the suitability under future scenarios revealed that more suitable areas will be lost under RCP8.5 compared to RCP4.5.

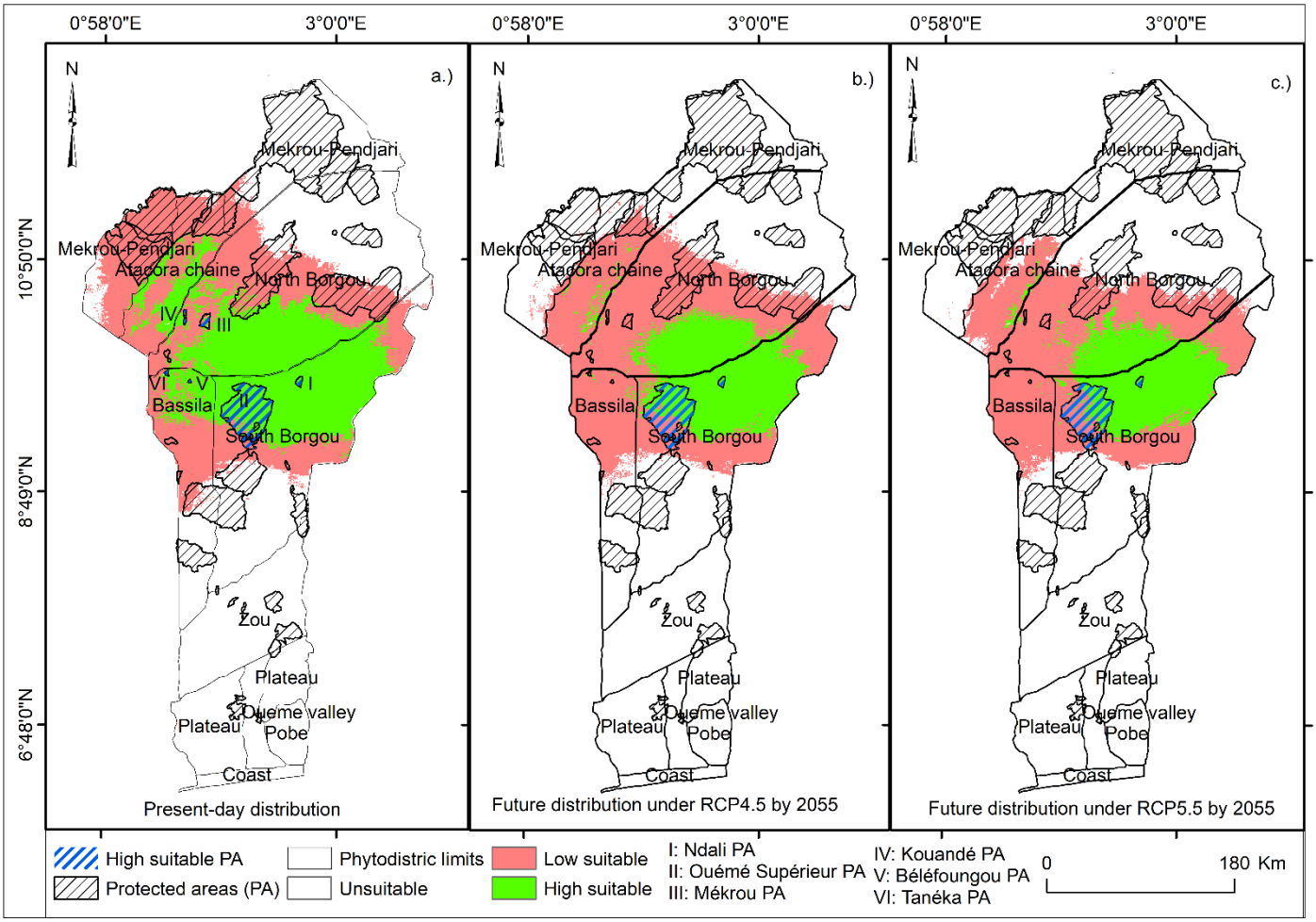

Figure 1. Distribution maps for of *Ipomoea beninensis*; (**a**) present-day distribution; (**b**) future distribution under RCP 4.5; (**c**) future distribution under RCP 8.5.

4. Discussion

This study assessed the potential geography and conservation areas of *Ipomoea beninensis* in Benin. Globally, models yielded very good performance (AUC value >0.80 and AUC ratio was 1.6). Our findings joined the previous reported by [1,7,11] on tropical species.

Five variables in particular were identified as the most contributing to the distribution of *I. beninensis*. The temperature (85.5%), through its mean diurnal range, seasonality, and its mean warmest quarter, as well as the rainfall wettest month (1.1%), contributed greatly to the models. These were associated with the elevation, which showed a high contribution (13.4%). This indicates that the species can withstand the annual temperature between 26 and 28 °C, annual rainfall between 1150 and 1300 mm, and the elevation range between 150 and 200 m. Overall, these variables largely represent climatic conditions of *I. beninensis* trees distribution, providing insights into underlying climatic factors, which delimits its suitable habitats. These results were in line with the findings of [1,12,13], who state that abiotic conditions represent one of the most important factors that determine the area in which a species is found. Moreover, high elevation locations have tended to be less impacted by habitat degradation due to direct human impact. Nevertheless, climate change threatens to increase these risks as upland areas become more suitable for agriculture [14]. The species thus has a restricted ecological amplitude for environmental conditions and consequently a very weak ecological plasticity highlighting its vulnerability to climate threats challenge.

The present results aligned with previous studies that reported the populations of *I. beninensis* as declining, due to the conversion of lands where the species is found into farmlands, with the over-exploitation of its organs for the treatment of human pathologies

and as fodder for animals [6], and will serve for its management practices (in situ and ex situ). In addition, under the future climate conditions, only one-third of the protected areas (N'dali and Ouémé Supérieur protected areas) could be suitable for its distribution. In fact, when habitats of an endemic species are lost by mismanagement and various other human activities combined with climate change threats, the distribution ranges, population sizes, and genetic variability of the species will be reduced and become vulnerable to extinction at a faster rate than other species [15]. Consequently, this species must be carefully monitored and managed to maintain biodiversity.

Results of this study did not address the relationship between biotic factors and their complex interactions with the abiotic factors, which influence the distribution range of species with much of the conditions that make up niche [16]. Thus, the limiting factors of species distribution are far more than environmental factors, highlighting the impossible to measure the true niche of a species completely. Therefore, modelling approaches should always be made with caution, and choosing modelling variables must be prioritised [16]. Even though these variables may not address those relations, the colonisation and extinction dynamics assessed in this study will be relevant to *I. beninensis* management policy, particularly when identifying new areas potentially suitable for its conservation.

5. Conclusions

The study suggests that despite the projected spatiotemporal dynamics, linked to climate change, the environmental conditions in Benin will remain favourable to the cultivation and conservation of *I. beninensis* by year-2055. We encourage the creation of a reserve or the reintroduction of *I. beninensis* in areas with high environmental suitability within the area of occurrence including the phytodistrict of Borgou (southern and northern), Bassila, and Atacora chain.

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