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Solving problems involving the distribution of a species of unknown distribution via ecological niche modeling

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ABSTRACT

Unlike species with widespread distributions, few predictive models have been constructed for species with restricted or unknown distributions. One example of such a poorly studied species is *Aristolochia gigantea*, for which very conflicting information has been reported regarding its distribution. In this study, we present *A. gigantea*'s distribution and range, the environmental factors responsible for its distribution and comments about the information available in the existing literature. The model of *A. gigantea*'s distribution identified new areas that can be surveyed to potentially find new populations, and our results reinforce the importance of predictive models for studying the distributions of species, suggesting that ecological niche modeling can provide important contributions to the analysis of biogeographic patterns in little-studied plant species.

Introduction

Conservation practices typically utilize information on species that are endemic or restricted to certain areas, or even the richness of higher taxa, to identify priority areas for conservation (van Jaarsveld et al., 1998). Thus, information on the distribution and range of focal species and an understanding of their biology are extremely important.

The analysis of the geographic distribution patterns of various taxa and at different spatial scales has increased in recent years (Guisan and Thuiller, 2005; Jiménez-Valverde et al., 2008). Among the tools used for this type of analysis, the most attention has focused on predictive species distribution models, in which the potential ecological niche of a species is modeled from various hypotheses as to how environmental factors control the distribution of species and communities based on known occurrence points (Guisan and Zimmermann, 2000).

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Such techniques are based on the fundamental niche concept proposed by Hutchinson (1957), which represents a niche as a range of conditions and resources in a hyper-volumetric space that is potentially exploitable by a species, disregarding biotic interactions with other species.

In general, spatial modeling converts primary occurrence data in the form of species records into geographic distribution maps that indicate the likely presence or absence of a species (Araújo and Guisan, 2006). The algorithms used for such conversions attempt to establish non-random relationships between the presence/absence data and the environmental variables relevant to the species (e.g., temperature, rainfall, topography, etc.).

Unlike with widely distributed species, few models have been applied to rare species considered here as those having low abundance and/or small ranges (according to Gaston, 1994); this is because their occurrence records are generally scarce and sometimes lacking data accuracy (Engler et al., 2004; Siqueira et al., 2009) due to small geographic distributions, low abundances or insufficient collecting. However, the application of the modeling technique utilized here is very useful in characterizing geographic distributions based on often-incomplete datasets, as with species for which little information is available and that may have errors in their reported distribution (Siqueira et al., 2009).

One example of a poorly studied species is *Aristolochia gigantea* Mart & Zucc, a basal angiosperm that, within the genus to which it belongs, is the most widely cultivated for ornamental purposes (Lorenzi and Matos, 2002), most likely due to the lack of a foul odor in this species. Natural populations of this species in Chapada Diamantina evidenced moderate to low levels of intra-population genetic variability, probably due restricted distribution of the species and small population sizes (Hipólito et al., 2012).

The first description of *A. gigantea* with details regarding species distribution comes from the work of Martius and Zuccarini (1824), and its natural distribution was reported in the state of Bahia, Brazil in the habitat in fences near the mountains of Jacobina that are in a desert place. Masters (1869) complemented that the plant is assigned to "mountainous" locations in Bahia and Minas Gerais, followed by Bellair and Saint-Leger (1899), who assign the origin only to Bahia; and Rodigas (1893), Costa and Hime (1981) and Capellari-Junior (1991) assign the origin to Bahia and Minas Gerais. Different information can be found in Barringer (1983) that recorded the occurrence of the plant in the rainforests of Panama and the Brazilian Amazon, although the author reports differences in the material from Central America and from South America, with larger flowers in the latter.

According to Capellari-Junior (1991), this species occurs in regions of the Caatinga biome, prefers damp areas such as riverbanks, secondary forests, pastures and road edges, and when cultivated, grows well in any soil. Its adaptability may explain the confusion regarding the origin of the species, e.g., the population reported by Barringer (1983) in the Amazon, which, according to Capellari-Junior (1991), likely originated from cultivated stock.

Herbarium records indicate that *A. gigantea* populations have also been found in several additional sites, including the Brazilian states of São Paulo, Rio de Janeiro, Santa Catarina and Paraná and outside of Brazil in Costa Rica, Panama and the United States. In some of these herbarium records, additional information is included on the occurrence of the species, such as whether it was natural or cultivated, but in others, this information is lacking, complicating the circumscription of the natural range of the species.

Thus, due to the inconsistency of the information available for this species coupled with the need for knowledge of the species' distribution, it is necessary to clarify the distribution of *A. gigantea*. In this context, this paper aims to (1) describe the distribution of *A. gigantea* and compare it in different models, (2) analyze whether there is an association between the species' predicted distribution of the species and the sites in which it is found, (3) evaluate the environmental factors responsible for determining the species' distribution limits, (4) analyze whether there is an association between the distribution and the information on this species reported in the literature and for all these aims to (5) explore the issue of using predictive species distribution models as a tool to perform or improve the assessment of unknown distribution species.

Material and methods

Study area

Because the natural distribution of *A. gigantea* is uncertain, we chose to construct distribution maps in two steps. The first step considered fine scale distribution maps with the goals of increasing the distribution model's accuracy and restricting predictions to the most likely occurrence limits and at the second step we aimed to indicate possible new areas of occurrence since no certainty exists about its natural occurrence.

Thus the first distribution maps included information found in older records commonly found in the literature, which name Bahia (BA) (Martius and Zuccarini, 1824; Bellair and Saint-Leger, 1899) and Minas Gerais (MG) (Masters, 1869; Rodigas, 1893; Costa and Hime, 1981; Capellari-Junior, 1991) as the areas of its natural occurrence. In addition, at the second step of distribution mapping we included the entire Brazil country.

Data collection

To model the potential geographic distribution of *A. gigantea*, we decided to combine historical herbarium records with recent field records. These points came from the region surrounding Chapada Diamantina, Bahia, totaling fifteen occurrence records from five different municipalities (Morro do Chapéu, Utinga, Lençóis, Itaetê and Rio de Contas). These records were obtained through active and systematic searches of the Chapada Diamantina region and nearby locations, with pursuits focused on areas close to small water bodies. The geographical coordinates of each location were recorded with the aid of a GPS unit, at points very close to where individuals were observed or in the approximate center of a population.

Other occurrence points were obtained from herbarium records and through the *Species Link* page (distributed information system that integrates primary data from biological collections URL: http://splink.cria.org.br/). Records containing