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Ecological Niche Modeling of Colchicaceae and Melanthiaceae of Nepal

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Abstract

Predictive models of species geographic distributions are important for a variety of applications in ecology and conservation. Ecological niche modeling of the two families Colchicaceae and Melanthiaceae was carried out using software DIVA-GIS 7.5 version, which was based on the presence data from herbarium records of BM, E, KATH, TUCH and TI and bioclimatic variables from WORLDCLIM. This work predicts the current potential geographic distribution of two families Colchicaceae and Melanthiaceae in Nepal. The current potential distribution indicated that members of Colchicaceae show somewhat dispersed distribution in all ecological regions whereas the members of Melanthiaceae are distributed in the Western and Eastern regions of Nepal.

Keywords: *Colchicum, Conservation, DIVA-GIS, Modeling*

Introduction

The family name Colchicaceae was first used by de Candolle and the taxonomic history of Colchicaceae began in 1805 (Kahraman & Celep, 2010). Colchicaceae is moderate sized family within Liliales, comprising around 19 genera and 250 species of rhizomatous or cormous perennials distributed through the temperate and tropical areas of Africa, Europe, Asia, Australia and North America (Nordenstan, 1998). No species occur in South and Central America (Vinnersten & Manning, 2007). Most authors however, continued to include it within a widely circumscribed Liliaceae. Members of Colchicaceae are known to contain the alkaloid colchicine, regarded as the biological hallmark of the family (Hegnauer, 1963; Raffauf, 1970; Vinnersten & Larsson, 2010; Wildman & Pursey, 1968).

The genera of Melanthiaceae were treated under the family Liliaceae by De jusseau (1789). Melanthiaceae comprise 11–16 genera and ca.154–201species in the world are predominately woodland and alpine perennial herbs occurring in the temperate zones occasionally extending to Arctic zones of the Northern Hemisphere (APG, 2009; Tamura, 1998; Zomlefer et al., 2001, 2003). They are mainly perennial herbs that are morphologically characterized by extrorse anthers and three styles (Zomlefer, 1997). In Nepal, *Paris polyphylla* (Satuwa) is one of the medicinal plants listed as vulnerable by the IUCN (Madhu et al., 2010).

It is well known fact that plant species are not homogenously distributed, each species depends on the existence of a specific set of environmental conditions for its long term survival (Gaston & Blackburn, 2000). To predict species potential distribution, many scientists have used BIOCLIM model of DIVA-GIS (Guisan & Zimmerman, 2000; Delanoy & Damme, 2006; Hijmans & Graham, 2006; Parthasarathy et al., 2006; Rajbhandary et al., 2010; Barman et al., 2011; Babar et al., 2012). Predictive models of species geographic distributions are important for a variety of applications in ecology and conservation (Graham et al., 2004), so to find the species distribution focused has been made on the genera of the families Colchicaceae and Melanthiaceae of Nepal. Thus, present work is based to predict the current potential geographic distribution of two families as Colchicaceae and Melanthiaceae of Nepal.

Materials and Methods

Total locality records of families Colchicaceae (127) and Melanthiaceae (188) of altogether 315 points of 10 species were used for distribution modeling. All these locality records were obtained from the herbarium specimens housed at different herbaria as BM, E, KATH, TI and TUCH. A set of 19 BIOCLIM (Table 1) variables for Nepal were extracted from WORLDCLIM (http/ www.worldclim.org) (Hijmans et al., 2005). All Bioclim layers consist of continuous data on precipitation, temperature and seasonality variables. WORLDCLIM contains Bioclim data at a spatial resolution of 2.5 arc sec (~5km^2) obtained by interpolation of climatic station records from 1950-2000.

Data cleaning

The initial record of presence points of Colchicaceae and Melanthiaceae were 315, after removing the multiple records the points were geo-referenced using ArcGIS 10.5 and still duplicate records were cleaned in 2min grid within each cell in order to minimize the spatial auto-correlation. The points were cleaned separately for each family. After removing the duplicate points, the final points for Colchicaceae are 46 and 56 points for Melanthiaceae. Then 19 bioclimatic variables were downloaded from worldclim dataset (www.worldclim.com). Pair wise correlations calculation was done and highly correlated variables were removed to minimize the impact of multi-collinearity and over-fitting of the model. The remaining nine (Bio 2, Bio 3, Bio 8, Bio 10, Bio 14, Bio 15, Bio 17, Bio 18, Bio 19) bioclimatic variables were used to model the distribution of Colchicaceae and Melanthiaceae of Nepal.

Ecological Niche Modelling

Ecological Niche Models (ENMs) are numerical tools that combine observations of species occurrence or abundance with environmental estimates. They are used to gain ecological and evolutionary insights and to predict distributions across landscapes, sometimes requiring extrapolation in space and time. It has been carried out for many types of organisms, especially with the application of DIVA-GIS (Guisan & Zimmerman, 2000; Delanoy & Damme, 2006; Hijmans & Graham, 2006; Parthasarathy et al., 2006; Rajbhandary et al., 2010; Barman et al., 2011; Babar et al., 2012).

DIVA-GIS also have an Ecological Niche Modeling tool which can be used to predict modeling with the use of Bioclim and Domain algorithms. Software DIVA-GIS provide an easy way to do the species distribution. In this study BIOCLIM model of DIVA-GIS 7.5 (a free Geographic Information System) was used for ecological niche modeling of 2 families (comprising 10 species) of Colchicaceae and Melanthiaceae that predicts suitability areas only in the neighborhood of occurrence records. BIOCLIM uses presence only data for distribution modeling. Based on climatic features of the data point locations it attempts to identify suitable and unsuitable areas in which the organism is likely to occur.

In this work, 50% data was used as test point and 50% data was used for modeling. For model

Table 1: List of 9 bioclimatic variables used for the species distribution of families Colchicaceae and Melanthiaceae (http:// www.worldclim.org/bioclim)

Bioclimatic Variables	
Derived from max & min temperature	BIO2 = Mean Diurnal Range (Mean of monthly (max temp -min temp))
	BIO3 = Isothermality (P2/P7) (* 100)
	BIO8 = Mean Temperature of Wettest Quarter
	BIO10 = Mean Temperature of Warmest Quarter
Derived from precipitation	BIO14 = Precipitation of Driest Month
	BIO15 = Precipitation Seasonality (Coefficient of Variation)
	BIO17 = Precipitation of Driest Quarter
	BIO18 = Precipitation of Warmest Quarter
	BIO19 = Precipitation of Coldest Quarter

validation, AUC curve and AUC values were used. The AUC value ranges from 0 to 1 where a value of 0.5 indicates that a model is no better than random and a value towards 1 indicates that the model can discriminate perfectly between presence and absence records (Warren, Glor & Turelli, 2010).

The environmental suitability value for each species was ranked under five classes that range from 0-34 percentile with different color (Table 2). The color indicated by brown i.e. percentile value d™0 means not suitable for species to occur. The dark green color i.e. percentile value 0-2.5 indicated low suitability of species to occur. Similarly, light green color with percentile value of 2.5-5 indicated the medium suitability of species to occur, while yellow color with suitability value 5-10 indicated high suitability of species to occur. Similarly, light yellow color with percentile value 10-20 indicated very high suitability of species to occur. Finally, dark red color with percentile value 20-34 indicated excellent suitability of species to occur.

Table 2: Species richness class with suitability value

Colour	Class	Suitability (Percentile)
	Not suitable	≤0
	Low	0-2.5
	Medium	2.5-5
	High	5-10
	Very high	10-20
	Excellent	20-34

Results and Discussion

Ecological Niche Modeling

AUC curve: The AUC values of Colchicaceae and Melanthiaceae was found to be 0.66 and 0.76 respectively, which explains accuracy of our model. The AUC curves are given in figure 1.

Majority of species of families Colchicaceae and Melanthiaceae, are concentrated in the central and eastern regions of Nepal (Figure 2). The model best explained the distribution of the Melanthiaceae species in the Western and Eastern part of Nepal with the high percentile value of 20-34. The potential

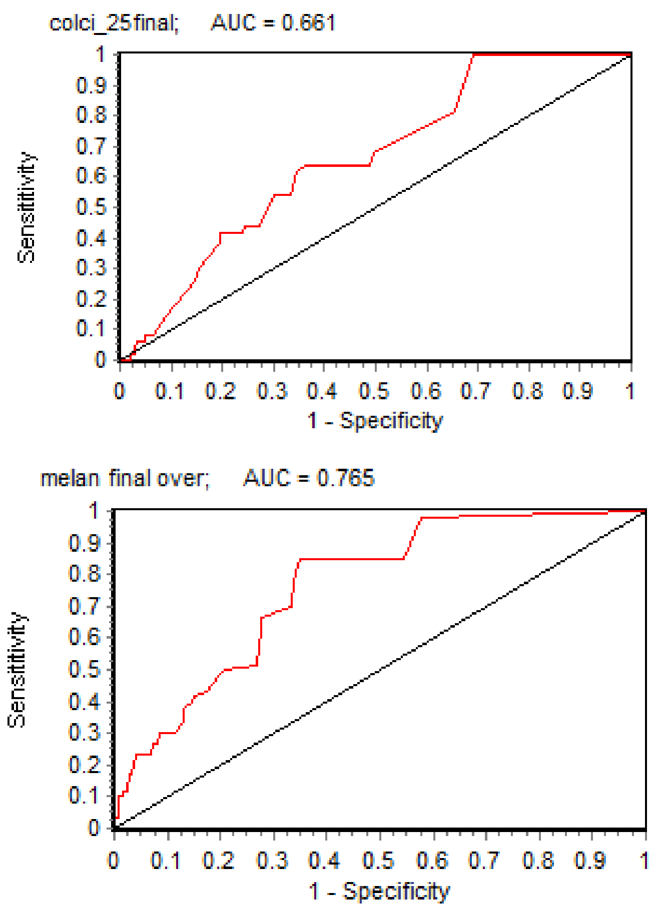

Figure 1: AUC curve of Families Colchicaceae and Melanthiaceae

distribution model of Colchicaceae shows somewhat dispersed distribution in all ecological regions of Nepal with high percentile value of 20-34.

The species of two families Colchicaceae and Melanthiaceae exhibited different distribution pattern. The suitability value of potential distribution model varies between these two different families. The adaptation to seasonal habitats limits the distribution of species in different regions (West-East) of Nepal (Rajbhandary et al., 2010). The areas with high percentile value indicates the high probability of species to occurred in the respected site and its surrounding areas and the sites with low percentile value indicates low probability of species to occur in that site. It can be only assumed that the areas with high percentile value are due to high exploration or field visit in that area. But, it could not tell that a species is not present only because it has not been observed. Maybe the species is hard to be found, or the habitat of the plant is difficult for people to get there (Wu Yun, 2006).

The species of Colchicaceae are distributed in the Central and Eastern region of Nepal. The potential distribution model shows somewhat dispersed distribution in all ecological regions of Nepal with high percentile value of 20-34. The species of Melanthiaceae are also distributed in the Central and Eastern regions of Nepal, while the model best explained the distribution of the Melanthiaceae species in the Western and Eastern regions of Nepal with the high percentile value of 20-34. These two families show the overlapping pattern in the distribution. The origin of the monsoon rains is the Bay of Bengal and hence the intensity of the rains decreases and its altitudinal onset increases as one travels from east to west across Nepal (Lillieso et al., 2005). The west to east increase in the species of Melanthiaceae and Colchicaceae is correlated with this increased intensity of the monsoon in the east supports the finding of Lillieso et al. (2005).

Most parts of the central and middle belts of Nepal are climatically suitable for species of these two families, where they are widely distributed due to moderate rainfall and temperature.

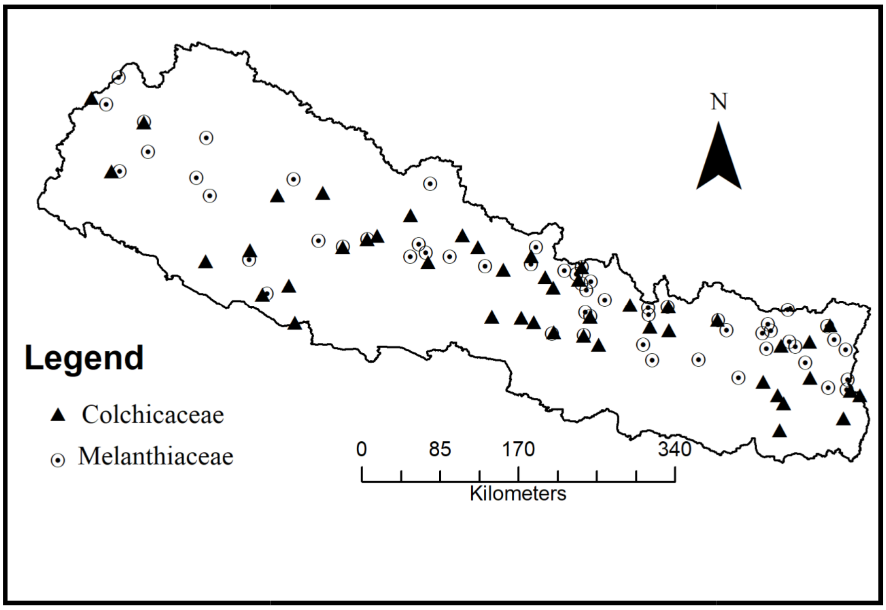

Figure 2: Overall distribution pattern of families Colchicaceae and Melanthiaceae based on herbarium records

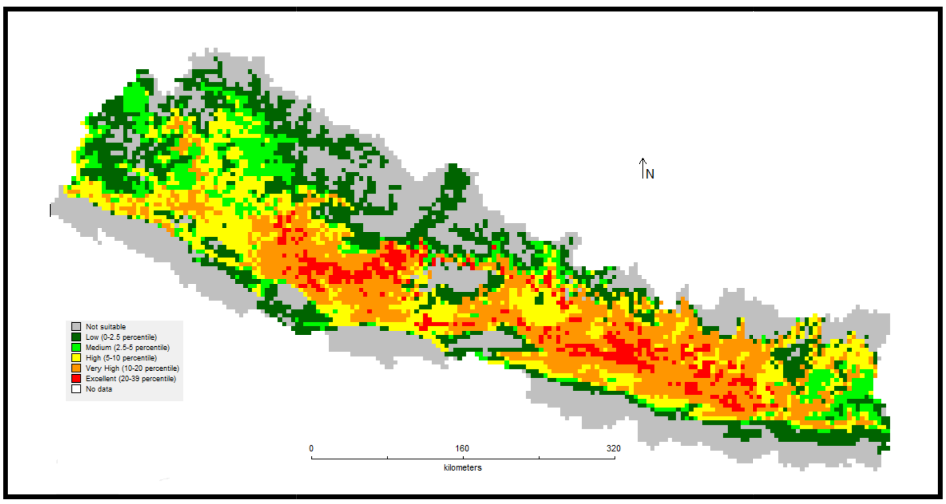

Figure 3: Current potential distribution of family Colchicaceae in Nepal

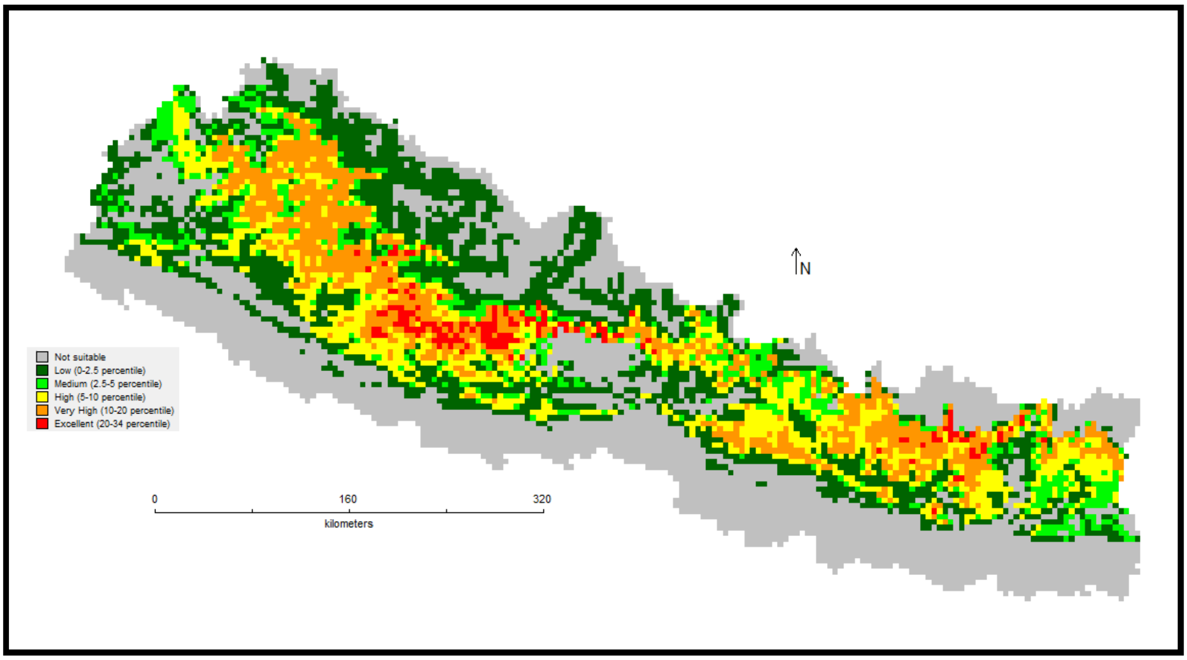

Figure 4: Current potential distribution of Melanthiaceae in Nepal

Conclusion

Present study described six genera and 10 species under two families Colchicaceae and Melanthiaceae. The family Colchicaceae includes *Disporum cantoniense*, *Disporum calcaratum*, *Gloriosa superba* and *Iphigenia indica*. The family Melanthiaceae includes *Paris mairei*, *Paris marmorata*, *Paris polyphylla, Paris thibetica*, *Trillium govanianum* and *Ypsilandra yunnaniensis*.

Regarding the distribution, the species are distributed from East to West but, more species are reported from East and Central region of Nepal, while least species are recorded from West Nepal. Vertical distribution of the species ranges from tropical to alpine regions of the country. The species of family Colchicaceae favours in the tropical to temperate zone (400-2900m) and the species of family Melanthiacaeae favours from sub-tropical to sub-alpine zone (1800-4100m). However, members under two families differ in their suitability value for potential distribution. Most species are recorded in temperate and sub-alpine zone and less from tropical and alpine zone. The current potential distribution model of family Colchicaceae shows somewhat dispersed distribution in all ecological regions of Nepal. While the species of family Melanthiaceae shows the distribution in Western and Eastern regions of Nepal. Species distribution models can provide valuable information about where species are likely to be found. Species distribution modeling can be a useful tool for data exploration to help identify potential knowledge gaps and provide direction to fieldwork design.

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