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Distribution mapping and conservation of *Rhopaloblaste augusta* (Kurz) H. E. Moore in Nicobar Islands, India

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Abstract: *Rhopaloblaste augusta* (Kurz) H. E. Moore is one of the threatened palm species endemic to Nicobar Islands. In order to know the distribution and conservation status of this palm, Maxent ecological niche modelling was used to predict the accurate distribution. The study revealed that high potential distribution of *R. augusta* was found in Great Nicobar and Car Nicobar islands; of the ten spatially unique points, six were from Great Nicobar, two from Camorta and one each from Katchall and Car Nicobar Islands. For islands like Tarassa, Chowra, Battimlav, Tinket and Nancowry, the model predicted significant influence of environmental variables in the distribution of species. High precipitation in warmest quarter, above 18 °C annual mean temperature and less temperature seasonality are the variables influencing distribution of this species. The islands of Nicobar group are rich in palm resources; however, habitats are extremely fragile owing to the prevalence of intense biotic and abiotic pressure. Urgent conservation initiatives are required to protect the existing endemic species richness of these islands.

Key words: AUC values, ecological niche modelling, GIS, maxent, Nicobar Islands.

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Introduction

The systematic conservation and management of biodiversity requires knowledge of the spatial distribution of resources (Margules & Pressey 2000). To identify threats and derive suitable management strategies to prevent species extinctions, the information on conservation aspects such as distribution, abundance and habitat quality are crucial (Baillie *et al*. 2004). Methods involving ground surveys covering entire study regions are either not possible or time consuming in most cases. Even the conventional approaches fail to synthesize the minuscule distribution details of a given species. New Geographical Information System (GIS) approaches have been developed to address this limitation by combining the known occurrence localities and environmental coverages that describes the study region. This approach has recently been explored under the rubric of "ecological niche modelling" (ENM) which produces potential distribution maps by establishing a relation between the known presence localities and background information (Soberón & Peterson 2005). ENM can provide diverse insights into the ecological and geographic extents of species' distributions (Soberón & Peterson 2004). In India, this technique has been widely applied to identify environmental niche of Himalayan birch (Singh *et al*. 2013), Malabar nut (Yang *et al*. 2013), Maramanjal (Thriveni *et al*. 2015), etc.

The genus *Rhopaloblaste* which belongs to subfamily Arecoideae of Arecaceae, forms threatened and vulnerable groups of plants endemic to South-East Asia (Uhl & Dransfield 1987). The plants are tropical rain forest palms occurring

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Fig. 1. *R. augusta* in Great Nicobar Islands.

from sea level to 900 m in lowland rain forest and in lower montane forest. *Rhopaloblaste* has a remarkably disjunct distribution (Baker *et al*. 1998) and among the six species, only one species *R. augusta* occurs in India and is endemic to Nicobar Islands. These Islands are rich in natural forest vegetation, lie in the eastern Bay of Bengal, and are the peaks of a submerged mountain range that connects western Myanmar with the large Indonesian Islands of Sumatra. *Rhopaloblaste augusta* shares these forests with other elegant palms such as, *Bentinckia nicobarica*, *Areca catechu* and rattans such as *Calamus andamanicus*, *C. dilaceratus*, *C. unifarious*, *Korthalsia rogersii* etc.. Kurz (1875) examined the occurrence of this species in Nicobar Islands especially in

Camorta, Car Nicobar and Great Nicobar Islands (Nicobar Islands, Camorta [Kamorta], Feb. 1875, *Kurz* s.n. (holotype CAL; isotype K). Mathew & Abraham (1994) mentioned occurrence of this palm in Nicobar group of islands without any precise locality. Later, this species was collected from the banks of Galathea river and Navydara point in Great Nicobar Islands (Sreekumar & James, 22 April 2001; 22632, KFRI); Katchal Island (Sreekumar, 23 April 2001; 11100, KFRI); Camorta Island (Sreekumar, 25 April 2001; 11101, KFRI) and different parts of Car Nicobar Islands (Linto & Manohara, 3 October 2008; 10671, KFRI). This is a graceful, slender solitary palm with pinnate leaves (Fig. 1); leaf sheaths are closed and form a prominent, green crown shaft; inflorescences are branched and borne below the crown shaft. Fruits are globose, ovoid and ellipsoid; orange, red or yellow; and one seeded. The name *Rhopaloblaste augusta* originated from Greek words; *'rhopalon'* meaning a club and *'blaste'* meaning a bud, which refers to the large club shaped embryo. IUCN (2013) placed this species under its "Vulnerable A1c ver 2.3" category (a decline in area of occupancy, extent of occurrence and/or quality of habitat). Ecologically *R. augusta* is a lowland palm in evergreen forests with *Bentinckia nicobarica*, *Planchonella longipetiolata*, *Endospermum diadenum*, *Garcinia xanthochymus*, *Adenanthera pavonina* and *Mangifera sylvatica* as dominant associates. This palm is also found among the other endemic flagship species of the islands like *Nothaphoebe nicobarica*, *Macaranga nicobarica*, *Aglaia spectabilis*, *Terminalia manii* and the keystone endemics like *Embelia microcalyx*, *Dillenia andamanica* and *Maesa andamanica* (Nayar 1996). This species is cultivated throughout the world for ornamental purposes and Nicobarese use it mainly as poles for construction of huts. The leaves are used as a thatching material for roofing.

Ecological Niche Modelling technique was used to construct the potential distribution of *R. augusta* in the Nicobar Islands and Maxent has been known to produce accurate distribution predictions for numerous rare and threatened species in a restricted study region (Elith *et al.* 2006; Pearson *et al.* 2007). An attempt was made here to produce accurate distribution map of *R. augusta* using ecological niche modelling framework, for understanding local distribution pattern and habitat requirements which is a fundamental goal of modern biogeography.

Materials and methods

Input data

A total of 10 spatially unique points of *R. augusta* was recorded during field surveys with Global Positioning System (GPS). The points were further geo-rectified with the Survey of India topographic sheets and Google Earth (Google, Mountain View, CA, USA) to obtain accurate coordinates to be used in the modelling. The background environmental data is given in the form of nineteen bioclimatic and six topographic variables. The bioclimatic variables are from the Worldclim dataset developed by Hijmans *et al.* (2005) available at a resolution of 1 km^2 (http://www.worldclim.org). The variables of annual and monthly values of mean temperature, precipitation and seasonality were derived. The topographic variables include elevation, slope, aspect, flow accumulation, flow direction and compound topographic index (a measure of tendency of water to pool). The topographic variables were derived from Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (http://topex.ucsd.edu/WWW html/ srtm30 plus.html) available at 30 meter resolution. All the geodata processing was done with the software ArcGIS.

Ecological niche modelling

The presence of only ENM or species distribution model (Franklin 2009) Maximum entropy (Maxent) modelling was chosen to predict the potential distribution of the *Rhopaloblaste augusta* in the Nicobar Islands. Maxent is a machine learning method which has its origin in the statistical mechanics. It is a general purpose method which makes predictions from incomplete information. The probability distribution of maximum entropy (closest to the uniform), subject to a set of constraints that represent the incomplete information about the target distribution (Phillips *et al.* 2006; Peterson *et al.* 2011). Maxent has shown to produce competitive results when compared with other general purpose modelling methods used in predicting the potential geographical distribution of a species (Elith *et al.* 2006; Wisz *et al.* 2008).

Maxent version 3.3.2e (http://www.cs.princeton.edu/~schapire/maxent/) was used to run the models. In the program, 500 iterations were run with a convergence threshold of 0.00001 and a maximum of 10,000 background points and algorithm parameters were set to auto features (Phillips & Dudik 2008). Only the random test

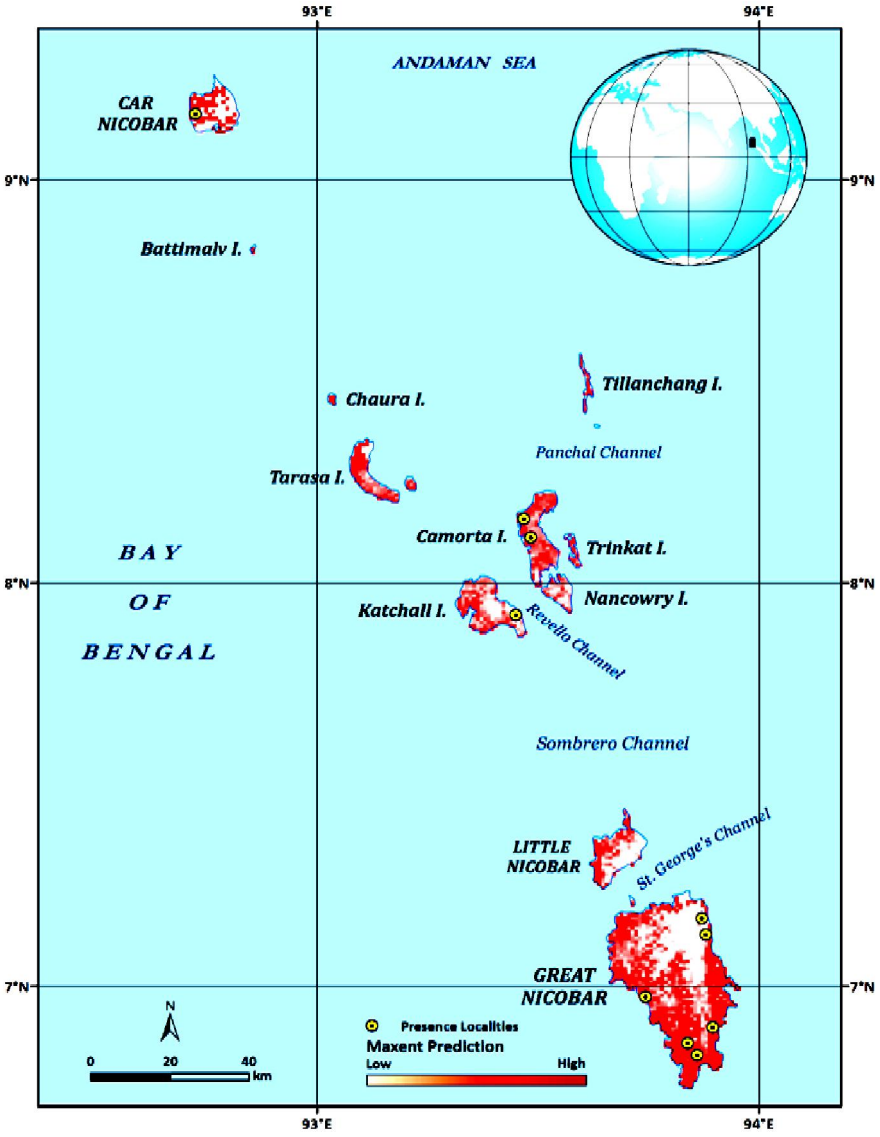

Fig. 2. Potential distribution of *R. augusta.*

percentage in the settings was turned to 20 % in order to test the model robustness through the Area under Curve (AUC). In addition to that, an external test was done through a jackknife test. By leaving one occurrence point at a time and running the model, it was allowed to predict the excluded point and the accuracy was tested through a simple probability test. Maxent produces predictions in the form of real numbers between 0 and 100 representing the cumulative probability of occurrence. The cumulative output format is chosen and the values were imported into ArcGIS as integer grids for further analysis and comparison.

Results and discussion

A jackknife test confirmed that the prediction is significantly better than at random ($P < 0.05$). The test and training Area under Curve (AUC) values were also higher (above 0.9) which implies that the model is accurate and justifies the construction of final niche model with all the available points. The prediction was good because the final niche model includes all the ten occurrence points in the Nicobar Islands. The predicted potential distri-bution of *R. augusta* is given in Fig. 2. The potential distribution is found to be more in the Great Nicobar and Car Nicobar Islands. Of the ten reported localities of *R.*

augusta, six were from Great Nicobar Island; two from Camorta Island and one each from Katchal and Car Nicobar Islands. Though there were no reported records from any other islands in the Nicobar group, the species was predicted to be present in the rest of the islands. This indicates the possibility of wider scattered distribution of this species in all Islands.

Table 1. Relative contribution of bioclimatic variables.

Variables	Percentage contribution
Annual Mean Temperature	58.4
Temperature Seasonality	21.3
Precipitation of Warmest Quarter	20.3

The Little Nicobar Island is situated between Great Nicobar and Katchal Islands between 7 - 8° north of equator separated by St. George's and Sombrero Channels and the eastern and northern parts of the island is predicted suitable. There is a possibility of the presence of *R. augusta* in smaller islands like Pulomilo, Treis/Albatei, Trak/Mafuya and Menchal in Little Nicobar's shores. The islands situated between 8 - 9° north of equator like Terassa, Chowra and Battimlav maxent model has predicted suitable conditions in all the three islands. The northern most known occurrence limit of *R. augusta* is from the Car Nicobar Island. The reported central distribution range is in the Katchal and Camorta Islands and the model has predicted suitable areas in the nearest islands such as Trinket, Nancowry, Tarassa, Tillanchong and Chowra. Maxent model gives the estimations of relative contributions of the significant environmental variables influencing the distribution of the species in a given region. In Great Nicobar Islands, main populations were located in the Galathea river banks, Navydera camp and Casurina bay. The contribution of environmental variables that influences the potential distribution of *R. augusta* in Nicobar Islands are shown in Table 1. Of the 19 bioclimatic and six topographic variables, only three variables viz., annual mean temperature, temperature seasonality and precipitation in the warmest quarter of the year positively influence the distribution of this species in Nicobar Islands which are located in the tropical region with a very stable equatorial climate. The updated Koppen-Geiger climate classification system (Kottek *et al*. 2006) includes the Nicobar group of islands into equatorial fully humid rainforest and monsoonal regimes. The majority of the islands fall within the first category where the coldest minimum temperature of a month will be above 18 °C and the minimum precipitation of the driest month is above 60 mm. The northern monsoonal regime is characterized by the majority of the rainfall occurring in winter (> 70 %). This characteristic of higher precipitation in the warmest quarter, the annual mean temperature which is above 18 °C and less temperature seasonality that might influences the biological requirements of *R. augusta*.

Small islands are the death-traps of endemic species which find no alternate habitats or biological corridors if disturbances of any kind occur (Nayar 1995). Though nearly 30 % of the Nicobar Islands are protected as nature reserves, the major threat to these islands arises from habitat loss due to the development activity (Sankaran 1997). The natural palm species in the islands faces decreasing population trends due to habitat destruction, poor natural regeneration and inability to compete with other plants. The Islands suffered great loss of forests and coastal biodiversity owing to its closeness to the epicentre of tsunami, i.e. just off the coast of Indonesia. Great Nicobar accounted for higher proportion of total the forest area damaged and submerged in Nicobar, followed by Central Nicobar (mainly Trinket and Kachal Islands) and Car Nicobar Island affected by tsunami waves and upheaval (Porwall *et al*. 2012). There is a considerable irrevocable loss of palm genetic resources in Andaman and Nicobar Islands due to tsunami especially on species like *R. augusta*, *Nypa fruticans*, *Phoenix paludosa, Licuala peltata*, *Bentinckia nicobarica* and other rattan palms (Manohara *et al*. 2010). Habitat fragmentation is one of the main problems because it adversely affects the special niches that the palms need to survive and establish. Hence, proper conservation strategies should be developed and implemented to prevent the genetic erosion and to ensure the conservation of endemics in the islands.

Conclusions

R. augusta is a low elevation evergreen palm endemic to Nicobar Islands. Indeed, much of its distributional area is already under protection, especially in Great Nicobar Biosphere Reserve, however, not much is known about the flowering and fruiting pattern and the natural regeneration of this species. ENM is a useful tool in outlining

and understanding the distributions, an application to focus on diverse conservation issues, including suitable habitat and species range estimates, and may prove useful in a variety of applications to biodiversity conservation, especially in protected area prioritization and network design. The prediction of distribution ranges of *R. augusta* was good because the final niche model includes all the ten occurrence points in the Nicobar Islands. The potential predicted distribution information of this species will be helpful in planning, conservation areas encompassing its existing populations, discover new populations, identify top-priority survey sites, and to set priorities to restore its natural habitat for more effective conservation. Further, to develop species specific conservation programmes, a detailed study on population structure, spatial ecology, reproductive phenology, seed dispersal and predation are recommended.

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