

BIOGEOGRAPHY OF *PIPER* SPECIES IN INDIA

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Biogeography is the science which deals with geographic patterns of species distribution and the processes that result in such patterns. It is the study of the distributions of plants and animals over the surface of the Earth in both space and time. The spatial component of biogeography attempts to describe and explain the distributions of one or more species over the world or the study area.

Biogeography is a synthetic science, related to geography, biology, soil science, geology, climatology, ecology and evolution (www.Biogeography,Wikipedia). Biogeography has many modes. It could be purely descriptive describing the distributions of particular species or habitats, the ecosystems. It is possible to explain very systematically with the help of GIS (Geographic Information System) by mapping the species distribution of ecosystems which is very important from a conservation and land management viewpoint. The spatial component of biogeography attempts to describe the distributions of species and the habitats favourable for their survival. A habitat is the specific, physical location of an organism, and it is a particular pattern for a particular plant or animal. Niche is the smaller unit of habitats. An organism's interaction with the abiotic factors of its environment (heat and moisture) defines its niche.

The distribution of *Piper* in India using GIS tools has been a little investigated. Trans-Gangetic region the Sub Himalayas and the South Deccan are considered to be the two independent centers of origin of the genus *Piper* in India (Hooker 1886). The sub mountainous tracts of Western Ghats are believed to be the centre of origin black pepper – *Piper nigrum* L. More than 1000 species

are included in the genus *Piper* of which 110 are of Indian origin (Hooker 1886, Purseglove *et al* 1981). Superficially, however, *Piper* species show relatively little morphological variation. In view of high species richness in the genus but relatively low morphological variability among species, Gentry (1990) suggested that much diversification in *Piper* may have occurred recently.

Niche of Indian *Piper*; Preliminary estimates suggest that the ideal temperature for the occurrence of *Piper* species is between 22 °C to 27.5°C and in the range of 26 to 28°C the frequency of occurrence is very high. Another climatic parameter that has significant influence on the distribution of *Piper* species is rainfall. The ideal annual rainfall is between 2200 to 2700 mm and the frequency of distribution of the *Piper* species is very high in these ranges even though *Piper* species do occur in areas receiving rainfall from 1500 to 3500 mm. According to Sadanandan (2000) well distributed rainfall within the range of 1000 to 3000 mm is best suited for proper growth and development of pepper. Inceptisols soil types are best for pepper growth, followed by Alfisols and Ultisols. Entisols are also good for pepper cultivation and all the low-lying coastal area and the riverbanks are considered Entisols, and pepper cultivation does well on them.

***Piper* species of Northeastern Indian niche;** The sub-tropical climate of Northeastern India is extremely favourable to the cultivation of black pepper in Arunachal Pradesh, Manipur, Meghalaya, Mizoram and Nagaland, but it is not fully exploited. Northeastern region is classified into following three broadly homogenous sub-regions:

- Himalayan hills of Sikkim and Darjeeling,
- Hills of Arunachal Pradesh, Meghalaya, Nagaland and Assam.

- Southern hills and valleys of Manipur, Tripura and Mizoram. (Anonymous, 2001). The North-Eastern Region of India has a total geographical area of 18.37 million ha of which about 55% is under forest cover. More than 90 *Piper* species are reported in the tropical evergreen forests and semi deciduous forests of North Eastern region. North East India is blessed with a wide range of climate, edaphic and altitudinal variations, resulting in a great range of ecological habitats.

Explorations were conducted by IISR scientists to North East region for collecting *Piper* species. The states surveyed include Meghalaya Mizoram, Arunachal Pradesh and Jalpaiguri district of West Bengal. Since the collected samples were in their vegetative phase, species level identification was not possible in many of the accessions collected except *Piper thomsoni* (male and female plants collected), and *P. peepuloides*. The collection sites were plotted on a map with the help of DIVA –GIS software. 2000 mm-3000mm is the range of rainfall in all the collection sites, and the optimum temperature is between 22°C to 27.5°C suggesting the suitability of climate for *piper* species 1000 m above MSL is the altitude of almost all the collection sites and the optimum altitude for the pepper is between 100-1000 MSL.

DOMAIN model of DIVA GIS (Hijjmal) was used to predict the potential distribution of *Piper* spp. in the NE India. In this model it is assumed that the climate at the points of observation and/or collection of a species is representative of the environmental range of the organism. The climate at these points was used as a calibration set to compute a climate probability model. Ten BIOCLIM climatic parameters were used to study the predicted distribution of *piper* species. Prediction for the suitability of pepper crop have drawn with DOMAIN model, which shows whole Northeast is suitable for black pepper except some portion of Meghalaya and Northern part of Arunachal Pradesh where altitude is above 1000m and rainfall is very high seasonally but not well distributed.

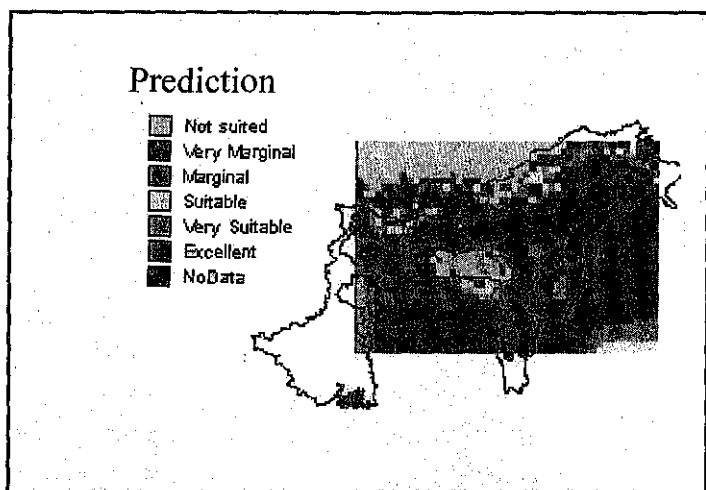


Fig.1. DOMAIN model of prediction of *Piper Sp.* In NE India.

***Piper* species of the Malabar niche.**

Kerala supplies about 97 % of the country's pepper production and sixteen species of *Piper* have been recorded to occur in different forest ranges of the state particularly in the Western Ghats. A commonly proposed hypothesis is that the number of species at a site is limited by the number of available niches (Pianka 1994). Most of the species of *Piper* in India are vine types possibly because they originate in the high rain fall forests. Study indicated that distribution of species is very poor in altitudes below 100 m above MSL. But maximum distribution occurs at altitudes of 100 – 250 m and between 750 and 1000m. The patterns of biogeographic variation in community composition of *Piper* species are much clear in the Western Ghats. Systematic surveys were conducted in 483 sites to collect *Piper* species in the Western Ghats. Among the soil types of Kerala, Ultisols constitute 54% of the land area, with Inceptisols (30%), Entisols (6%), Mollisols (1%) and Alfisols (1%). Among these, Inceptisols are best for pepper growth, followed by Alfisols and Ultisols. The collection areas have these soil types. The annual rainfall of Kerala is between

2200 and 2700 mm, which is ideal for piper species, even though *Piper* spp. are found in areas with an annual precipitation of 1500 to 3500 mm.

Data collected were plotted in the map with the help of Logitude and latitude using DIVA-GIS software. The superimposed map (fig-3) of BIOCLIM annual precipitation and species distribution indicates that *P. longum* naturally occurs in the high rainfall zones receiving more than 4000mm rainfall, while the rest of the species are present in regions receiving 1500 to 3000 mm rainfall. A well distributed rainfall within the range of 1000 to 3000 mm is best suited for proper growth and development of pepper. The annual rainfall in all the collection sites ranged from 1500 to 4000 mm. Species such as *P. babubudani*, *P. thomsoni*, *P. longum* and *P. galeatum* are found in areas receiving rainfall of over 2000mm and upto 4000 mm. Even though, such studies on Indian *Piper* species has not been reported.

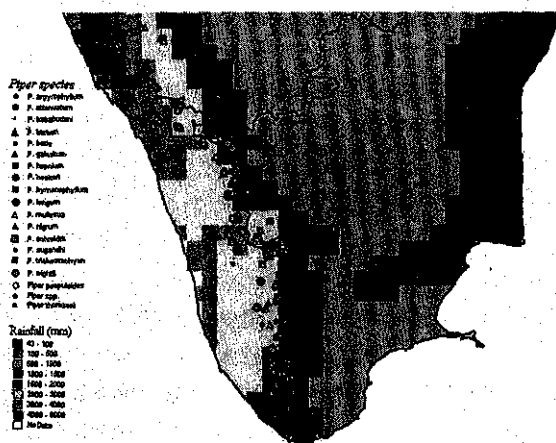


Fig.3. Precipitation Map of southern India and piper species distribution drawn with the help DIVA-GIS.

However, reports in case of neotropical *Piper* indicate that highest species richness occurs in three high rainfall regions of Amazon (Gentry, 1989 and Marquis, 2004). The BIOCLIM model of

DIVA-GIS uses a set of 15 of the available 24 climatic variables loaded with the programme and most of these variables are those that are likely to affect the ecological domain/niche of the species (Ganeshiah *et al* 2003).

The map with species and collection sites implies that climate and soil have an impact on distribution of wild *Piper* species. *P. attenuatum*, *P. hymenophyllum*, *P. argyrophyllum*, *P. longum* and *P. nigrum* are found in almost all the districts of Kerala. *P. galeatum* and *P. trichostachyon* were found at medium elevation (1500–2500 m) in Idukki, Pathanamthitta, Palaghat and Wynad Districts (Ravindran *et al.* 1992). *P. hapnium*—an endangered species listed in the red data book of the Botanical Survey of India—was collected from the Sabari hills and Achankovil forests of Pathanamthita District, and the Kuttikanam areas of Kottayam District at between 300 and 600 m. *P. barberi* is considered an endangered species, and was found in the Agasthimala area, and re-described (Nirmal Babu *et al.* 1992). High-elevation species like *P. schmidtii* and *P. wightii* are distributed on the tops of the Munnar hills, Idukki District, while *P. mullesua*—a medium climber with globular spike—is found at between 2500 and 4500 m on the Western Ghat hills of Idukki Wynad and Palaghat Districts. *P. silentvalleyensis* (Ravindran *et al.* 1997), the only bisexual wild species reported from south India, was found in the deep forests of Silent Valley, Palaghat District.

Species richness and diversity analysis

The Shannon diversity index revealed that, there are two hotspot areas of richness (fig-4) one in between 75°92'–77°06'E longitude and 10°95' - 11°03'N latitude consisting Achankovil, Kulathapuzha, Silent Valley and Tirunelly of Kerala, and Nilgiris of Tamilnadu. Another is in the extreme south in between 77°02'–

77°96'E longitude and 8°12'-8°98'N latitude consisting of Neyyar and Poovanathmodu of Kerala and Brymore, of Kanyakumari district Kodayar, Kariardam, and Kannikatty of Tirunelvel district of Tamil Nadu, where 7-8 species are available in the same site. The distribution map shows the altitude varies from 300-1000m in Northern hot spot of south India and it varies from 200-500 in Southern hot spot. The hot spot grid includes 15/16 species under observation. This method is used because it is a simple, widely used, well understood and a useful measure of taxonomic diversity (Gaston 1996). It is less sensitive than diversity indices to the problems of poor sampling intensities and procedures (Hijmans *et al* 2000). From the Diversity index map (fig-5) it was found that Coorg district of Karnataka, Nilgiris and Tirunelvely of Tamilnadu and Wanayad and Palghat districts of Kerala have the highest diversity index. Richness shows the existence of the species while diversity index shows the density of the species and altitude ranging from 300M to 700M was found to have high diversity. (Utpala *et al.* 2006)

P. nigrum is distributed in almost all the collection sites at high or low altitudes. Low altitude species like *P. argyrophyllum*, *P. attenatum* and *P. longum* were not found in the hotspots. Based on our study the species can be broadly divided into three groups. The first group occurs in high altitude (500-1500M) such as *P. babubudani*, *P. galeatum*, *P. trichostachyon*, *P. hymenophyllum* and *P. sugandhi* the second group grows at medium altitude (100-700M) include *P. barberi*, *P. thomsoni*, *P. longum* and *P. nigrum* and the third group occurs at lower altitudes (50-150m) include *P. argyrophyllum*, *P. attenatum* and *P. hapnium*. Absence of random mating and free gene flow in *Piper* has led to isolation of small population and this population must have undergone divergence through segregation (Ravindran *et al* 1997).

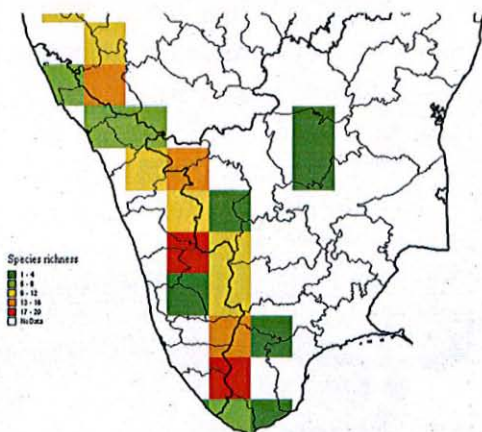


Fig. 4. A map of southern India showing *piper* species richness

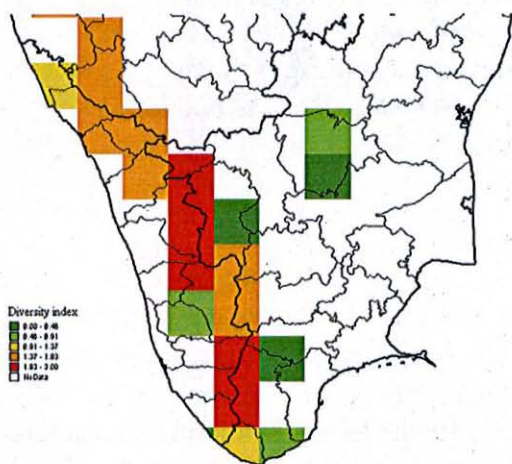


Fig. 5. A map of Southern India showing *Piper* species diversity index

Prediction of high potential areas of habitat

Using the collecting data from Western ghats, DIVA-GIS was used to predict the distribution of *Piper* species in other parts of India (Figure 6). From the figure it is evident that, besides Kerala, *Piper* species must be available in parts of Karnataka and many areas in Tamil Nadu and Srikakulam District of Andhra Pradesh. Most areas of north-east India, coastal Andhra Pradesh, Orissa and

West Bengal are also likely to have many *Piper* species. It is clear that species occurrence is highly correlated with climatic conditions.

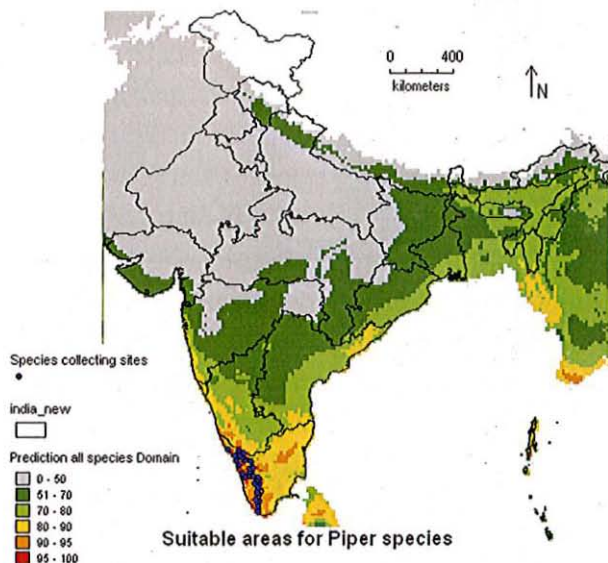


Fig. 6. Prediction distribution patterns and/or suitable sites for their cultivation in India

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