Biodiversity of *Piper* in South India and application of GIS and cluster analysis in search of its distribution

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Abstract

The Western Ghats of south India and the north eastern India are the two hotspots of diversity of the genus *Piper* in India. The Western Ghats of peninsular India is presumed to be the centre of origin of black pepper in view of its vast occurrence and diverse distribution in wild. The Indian Institute of Spices Research, Calicut has made a considerable collection of *Piper nigrum* and its wild relatives from southern India and North Eastern India.

The 15 important qualitative morphological characters of 16 wild species of southern India were studied and plotted for the hierarchical clustering. A dendrogram was drawn using Centroid average linkage between groups, using SPSS software.

Four major clusters and seven sub-clusters were found. where as *P. argyrophyllum*, *P. attenuatum* are found forming first pair are low to medium altitude 50-700 m species. while *P.peepuloides* of the first cluster has a wide range 150-1000 M . P.*hymenophyllum i*s the only member of 2nd cluster and forming a separate group its relation with all other groups are below 35%. P.*longum* and P.*thomsoni* forming the 3rd cluster with a similarity value of 82% and both occur at low altitude while P.*thomsoni* is also persist at high range (1000M) of N.E .Himalayan foot hills. *P.nigrum* and *P.babubudani* which are very close with a correlation value of 0.942(94%) similarity are the member of 4th cluster. *P.nigrum* has a wide range of altitude 100-700M. Presence of the same group of species in the same location or the nearby location indicates greater degree of geographic relatedness among the species and their origin.Species richness and Species diversity index was also studied which shows Wayanad and Palghat district of Kerala, Nilgiri and Tirunelvely of Tamilnadu are the hotspot of species richness.

Introduction

The genus *Piper*, the largest in the family Piperaceae consisting more than 1000 species occurs throughout the tropical and sub tropical region. The distribution of *Piper* ranges from sea level to the high ranges of Andes and the Sub Himalayas (Royle, 1893). Trans-Gangetic region 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 nigram* L. More than 1000 species are included in the genus *Piper* of which 110 are of Indian origin (Purseglove, 1981; Hooker, 1886).

Piper species occurring in South India are economically important, as they are closely related to the cultivated black pepper. *P. betle* L is another economically important species which is mainly used for pan industry. Several species of *Piper* are used as important medicinal plants. P. *longum*, P. *cubeba*, P. *retrtofractum* etc. are some of the species used in indigenous medicine system.

The genus *Piper* was established by Linnaeus. The first report of *Piper* species of the Malabar region was by Van Rheeda in his 'Hortus Indicus Malabaricus' in which he describes five species of which four were illustrated. Linnaeus (1753) described 17 species and assigned five of them to Indian peninsula. Gamble (1925) in his Flora of Presidency of Madras described 14 species.

The hierarchical clustering is a visual representation of the closeness or the distance of the species. A dendrogram scales the actual distance or the relative ness of the species. The SPSS Centroid Method preserves the ratio of the distances between steps .In this paper the qualitative characters have taken to scale the species. Ravindran (1997) has done the principal component analysis the genus *Piper* with the aim to group the related cultivars .In the present study morphological grouping of the species have compared with the environmental variables with the help of DIVA GIS software. It has been recognized that the distribution of plants is primarily constrained by climate. This concept has underpinned many attempts to predict the potential distribution of individual species through correlation of climate with spatial distribution of individual species

Materials and Methods

Systematic surveys were conducted to the major *Piper* distributed area of both the centres of diversities viz., the Western Ghats and North Eastern region. Live specimens was collected and established in the black pepper germplasm conservatory of Indian Institute of Spices Research, Calicut. Herbarium was also prepared by fixing them in FAA and pressing them with the help of a hand press. The altitude, longitude and latitude of the collection site was recorded using GPS. Wherever this was then not possible (in the dense forest, where satellite connection was not possible) geographical information of the nearest open place was recorded. The data was plotted using a DIVA. GIS software supplied by IPGRI. 15 qualitative characters was recorded from the samples collected (both live specimen and herbarium). The character was computerized and using SPSS software for cluster analysis (15 characters of 16 species). The Cluster got with the help of Centroid Method was compared with altitude and rainfall, the two important aspect influence the distribution of pepper

Result and Discussion

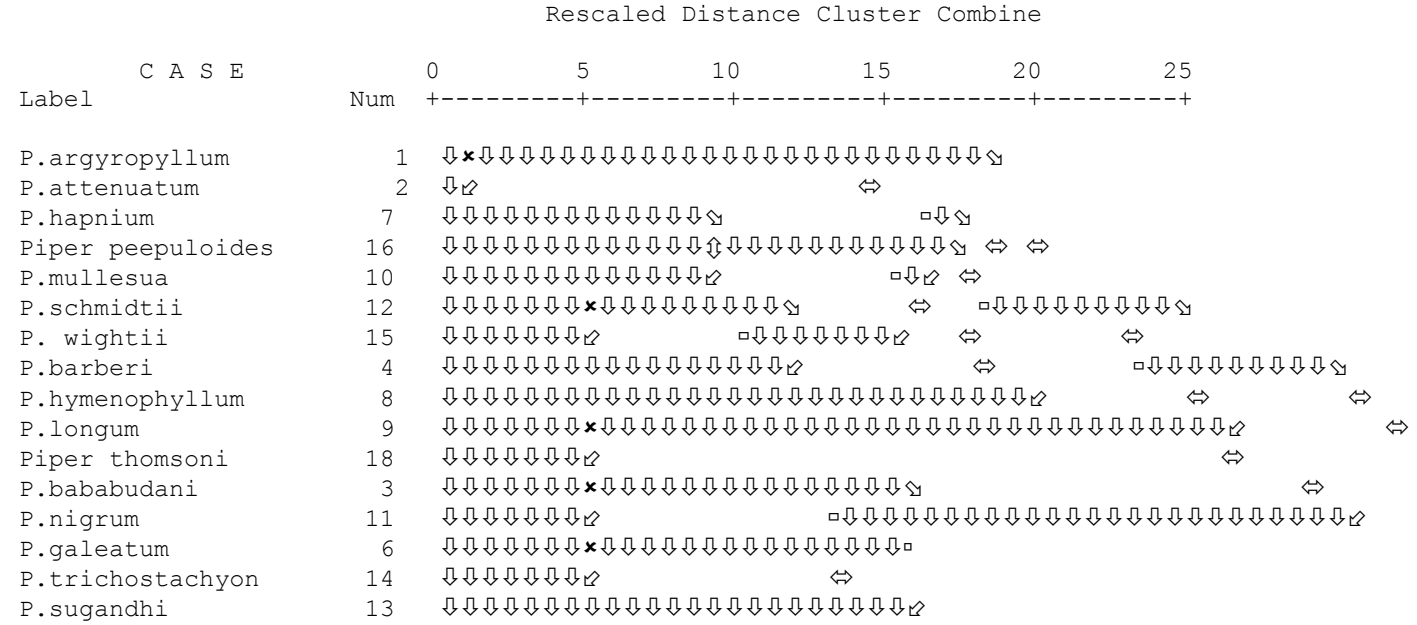
A perusal of the dendrogram and the Table 1 would indicate that P. *argyrophyllum* and P. *attenatum* are closely related species with 94% similarity between them. They are not close to any of the species under study and very distant to *P.longum, P.nigrum P.galeatum* and *P.sugandhi*. When the distribution and altitude maps were superimposed it was found that both having a wide range of altitude distributed between 50-700m. Ravindranan *at el* (1992) also reported a separate cluster for these two species. Hooker (1886) included them under Eupiper.

The next group of the 1st cluster consists of P. *hapnium* *P.peepuloides* and P.*mullesua* where P. *hapnium* and *P.peepuloides* are having 55% similarity between them. P. *hapnium* is a comperatively low altitude spice 150-300M while *P.peepuloides* has a wide range 150-1000M. In case of *P. mullesua* the similarity varies between 45and 65% while it is a comparatively high altitude species available up to 1500M.

	yopyll ɲ	ɛbtiat ɲ	ɔabud i	ɜrberi	eatum	ɜpnium	ɲenophy ll	ɔngum	mullesua	ɔ.nigrum	schmidtii	ɜugandhi	chostac h	ightii	iper ɔulo	ɛr thomson
yopyllum	1.000															
ɛbtiatum	.940	1.000														
ɜabudani	-.048	.032	1.000													
ɔberi	.340	.342	.091	1.000												
ɛatum	.222	.093	.732	.291	1.000											
ɜnium	.000	.132	.387	-.029	.047	1.000										
ɲenophyll	.357	.200	-.233	.017	.169	-.603	1.000									
ɜgum	.087	.059	.045	-.191	.021	.185	.201	1.000								
ɜllesua	.394	.331	.468	.230	.445	.458	-.101	.333	1.000							
ɜgrum	.047	.048	.942	.255	.842	.220	-.132	-.027	.479	1.000						
hmidtii	.197	.099	.468	.632	.773	-.125	.251	-.185	.417	.619	1.000					
gandhi	.153	.154	.726	.512	.689	.258	-.156	-.286	.420	.851	.645	1.000				
chostach	.000	-.041	.811	.197	.903	.233	-.031	-.138	.311	.845	.674	.763	1.000			
ghtii	.592	.596	.529	.776	.702	.125	.101	-.074	.458	.639	.750	.710	.596	1.000		
r peepulo	.306	.274	.284	.044	.266	.559	.026	.783	.645	.237	.043	.067	.107	.258	1.000	
r thomson	.072	.049	.037	-.158	.017	-.061	.166	.828	.275	-.022	-.153	-.237	-.114	-.061	.427	1.000

This is a similarity matrix

Dendrogram using Centroid Method



Next pair of the clusters contain *P.schmidtii and P. wightii*are very high altitude species occur at 1000—25000m. P.*barberi* is the last member of the 1st cluster and it is available at an altitude of 600m, but the nearest member is *P.wighti* having correlation value .77. It is interesting to note that P.*barberi* is having very low (12-20%) similarity with all other species except P.*sugandhi* with which its similarity is above 50%.

P.*hymenophyllum i*s the only member of 2nd cluster and forming a separate group its relation with all other groups are below 35%. It is present at a medium altitude 200-800m. and present in almost all the collection sites of the altitude range.

P.*longum* and P.*thomsoni* forming the 3rd cluster with a similarity value of 82% where P.*longum* is present at an altitude 50-150m and P.*thomsoni* occur at 60-1000m and it is avaible in the Himalayan foot hills the species was collected from North Bengal. Here it is to mention that other than P.*longum* the relation of P.*thomsoni* with all other species are very low. Another point to note is that P.*longum* is a creeper by habit while P.*thomsoni* is a bush, Murthy(1985) has mentioned that P.*longum* has a distinctive anatomy. A look at the similarity table tells that its relation with all other low altitude species like P. *argyrophyllum* ,P. *attenatum* and *P.nigrum* is very low (2-4%).

The first pair of the 4 th cluster consists of *P.nigrum* and *P.babubudani* which are very close with a correlation value of 0.942(94% similarity) and may very well be the one and the same species. *P.bababudani* was collected only from Coorg at an altitude 500-1000;

P. *nigrum* is distributed in medium altitude but it is also available at 50 m., but main concentration is visible in 300-700 MSL

P.galeatum, P. sugandhi and *P.trichostachyon* are the other species of 4th cluster that could very well be the same as *P.nigrum*. P.*galeatum,* and P. *trichostachyon* are very close in the cluster with a 90% similarity. These two are treated accordingly by Hooker (1886), Gamble (1925) and Ravindranan(1992) as the member of the same cluster.

P.*sugandhi* is also clustering along with them but having 70% similarity and all are high altitude loving species(300-1000m) but P. *trichostachyon* sometimes available at low altitude. Ravindran e*t al*(1990) suggested P. *galeatum* and *P. wightii as* the progenitors of *P.nigrum* but the distribution map showing the collection site of both the species are apart from each other. Crossing studies and cytological studies would prove the species status.

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Name of species	Approximate Altitude	Cluster no.
P. *argyrophyllum* P. *attenatum*	50-700 M	1-a pair
P. *hapnium* and	150-300M	1
P.peepuloides	150-1000 M	1 one group
P. *mullesua*	700-1500M	1
P.s*chmidtii* and P.*wightii*	1000-2500M	1-a pair
P.*barberi*	600-M	1-Single number
P.*hymenophyllum*	200-800M	2-Single number
P.*longum*	50--150	3
P.*thomsoni*	60-1000	3 a pair
P.nigrum.	50-700 M	4
P.babubudani	500-1000	4 a pair
P.*galeatum,*	300-1500	4
P. *trichostachion*	300-1500	4 one group
P.*sugandhi*	600-1400	4

Table no-2 showing the species ,approximate altitude and the cluster number.

The precipitation distribution of the pepper collection site was studied but it was found that rainfall is not having much influence on the species distribution. P. *nigrum* the very common specie has a wide range of rain fall 1000mm-5000mm

Species Richness

Species richness map prepared with the help of DIVA-GIS software shows two hotspot areas one in between 77°02'-77°94'E longitude and 8°32' -8°98'N latitude consisting Achankovil, Kulathapuzha, Silant Valley and Thirunelly of Kerala, and Nilgiri of Tamilnadu. Another one is in the extreme south in between 67°-76°86'E longitude and 11°08'-12°N latitude consisting of Kodayar, Neygar and Poovanathmodu of Kerala and Brynoore, Kariardum, Kanikatty in Tirunelvely district of Tamilnadu, where 7-8 species are available in the same site The distribution map shows the altitude varies from 300-1000m in Northern Kerala and Karnataka and it varies from 200-500 in southern Kerala and Tamilnadu .

Species Diversity

When the Diversity index map was discussed it was found that Coorge district of Karnataka,Nilgiri and Tirunelvely of Tamilnadu and Wanayad and Palghat districts of Kerala is showing Highest diversity index. Richness shows the existence of the species while diversity index shows the density of the species and when correlated with the altitude map shows 300M to 700M is having high density, when the rainfall was considered it was found that 1500-2500mm rainfall is prevailing in the high density region.

The present study reveals that the low altitude species are having considerable distance from the high altitude species in the dendrogram. *P. nigrum* is available in almost all the collection site in high or low altitude. The hotspot points are not having low altitude species like *P. argyrophyllum P. attenatum and P.longum* . We can broadly divide three

sets of species. One grows in a high altitude varies between 300-1000 and another in medium height of 100-500m and the third one 50-150m and they are not present in the hot spot areas .According to Ravindranan *at el* (1997) absence of random mating and free gene flow in *Piper* leads to isolation of small population and these population must have undergone divergence through segregation. The variation noticed in the Western ghats species are may be due to the change for meeting the challenge of struggle for existence. A comprehensive collection of the N.E.Himalayan species and the comparative study could throw light on the relationship among the species.

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