

THE VEGETATION OF THE RAJGHAT RAVINES

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I. SITUATION, TOPOGRAPHY AND DEVELOPMENT OF THE RAVINES

A LARGE number of ravines bearing forest growth dissect the sides of the plateau of Rajghat as it stands to the north-east of Benares town separated from it by a depression carrying the Grand Trunk Road and Kashi station of the East Indian Railway situated on the ridge. The plateau itself is a rectangular area about $\frac{3}{4}$ mile long and $\frac{1}{4}$ mile broad with the Ganges scoring on the south and the river Barna circumscribing it on the north and the east where it meets the former river (Fig. 1). It is about 255 feet above the sea and the rivers run 55 feet below during the dry season. The exposed banks of the rivers are then cultivated.

The ravines are formed on account of gully erosion. The monsoon bringing the rain releases it generally in a torrential down-pour during the rainy season. The water collecting and running on the periodically rain battered ground of the plateau scores out small gullies. As the various ramifications of these unite and the intensity of soil erosion increases with the increasing volume of running water the ravines are dug deeper and wider at lower levels when approaching the rivers. Occasional landslides cut the sides precipitously giving them the appearance of deep gorges. The top of the plateau slopes gradually from the south to the north and hence the ravines are longer towards the Barna than those running into the Ganges.

II. HISTORY AND BIOIC FACTORS

Although the development of the ravines is so rapidly ruinous to the plateau yet it has a marvellously long history of existence though undoubtedly getting spatially narrowed on the north and the south. The area was once thickly inhabited as is clear from the traces of old buildings, the Rajghat Fort and from the more recent excavations conducted by the department of Archæology. It is now the property of the Rishi Valley Trust who have built on the site a residential school and college. The buildings including the old temple of Adikeshwar extend up to the confluence of the rivers.

The stability of the plateau is chiefly dependent on the interesting vegetation of the ravines which has appreciably slowed down the progress of erosion if it has not already arrested it at certain places. Wherever the growth of this vegetation has been interfered with it

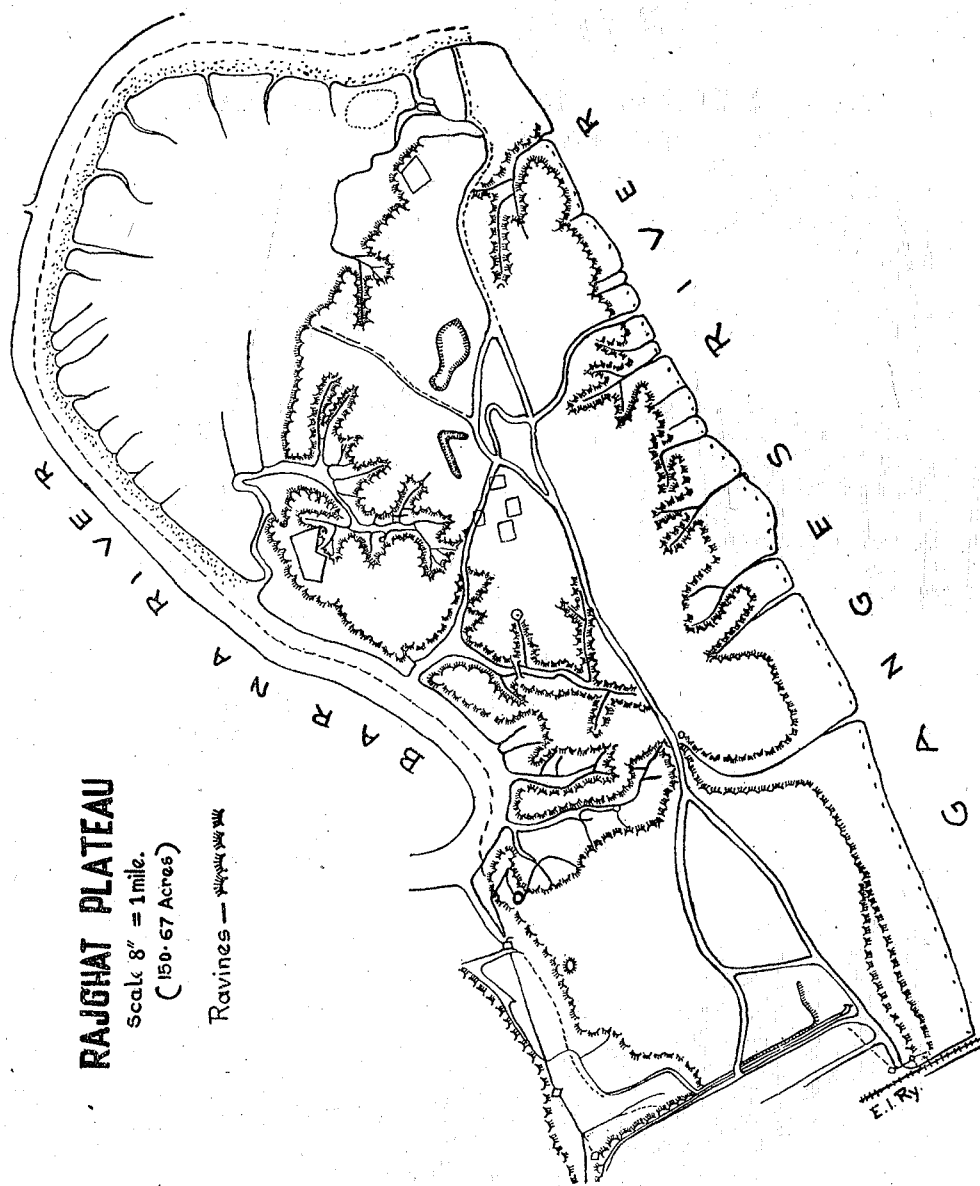


FIG. 1

has led to ruin and misery. The clearing of the vegetation for the archaeological excavations on the south-west corner of the plateau and the college buildings on the north-eastern ridge has already made their position precarious. Further, the ravines contain abundant remnants of buildings including a huge stone gate of the old fort which has collapsed on the Barna side. These point to the havoc wrought by erosion due to the destruction of the vegetation subject to periodic pressure of human population on the historical plateau.

Clearing of the vegetation especially about a ridge or a rudimentary ravine for building purposes is therefore a process ruinous to the vegetation and the plateau. Felling the trees for timber and fuel and lopping are common practice and continuous grazing of cattle, sheep and goat limit the growth of the forest in the ravines. Scraping of the ground vegetation which may at times cover parts of the plateau exposes the loosened soil for rapid erosion. Most of the herbs including the taller rainy season annuals dry up in the cold season when they are collected for fuel and not allowed to decay on the soil which might improve its fertility.

III. CLIMATE*

The periodic climate of Benares is typical of the Upper Gangetic Plain with an annual average rainfall of 40 inches. The rainy season extends from about the middle of June to September when nearly 36 inches of the fall are obtained; July and August being the wettest months. The average number of rainy days in the season is 20 per month, and the mean relative humidity is about 88%. The mean maximum temperature during the period is about 90.5° F. and the corresponding minimum is 78° F. This is the most favourable season for plant growth as it follows the dry hot summer.

The bright month of October is rainless and calm. The mean maximum temperature is 94.7° F. but the mean minimum is 65.6° F. on account of the cooler nights. This is followed by the cold season of 4 months when the days are cool and bright with a breeze from the west. The nights are cold and humid. There may be a little rainfall late in the season but it seldom exceeds 2 inches in any month. The mean maximum and minimum temperatures for the season are 80.8° and 52.8° F. and the mean relative humidity is 79.9%.

The month of March is a mild warm period of transition between the cold season and the following hot season; the latter extends from April to the middle of June. The mean maximum temperature during the hot season is about 105° F. but the absolute maximum temperature may go upto 115° F. in May. Dry hot wind known as "loo" blows strongly from the west during the day time. It desiccates plant tissues very often killing them. But the narrower ravines are not much exposed and as the wind sweeps over the rivers before turning into them the protected vegetation does not suffer much on this

* The figures given in this section are based on records for 1942-43 (Misra, 1944).

account. The nights are not so hot and the mean minimum temperature for the season is 76.6° F. The mean relative humidity for the period is about 48%. The weather becomes stormy at times with occasional drizzles following dust. However, erosion of soil by wind is moderate.

The ravines in the south to the Ganges side receive more of sun than those in the north towards the Barna. This factor seems to be responsible for differences in the floristic details of the plant communities present in the two systems.

IV. SOIL

The plateau consists of a fairly uniform deposit of an old alluvium on a bed of 'kankar'; the latter is found locally exposed on the bank of the Barna. The soil is light being moderately porous and gray and brown coloured with small rounded grits and calcareous nodules. It is alkaline with pH values ranging between 7.90 and 8.34 and it gives a strong positive reaction for nitrates when tested with a 0.02% solution of di-phenyl-amine in concentrated sulphuric acid (Misra, 1944). The ravines at their lower approaches to the river get covered with newer sandy deposits every year on inundation when it is in spate during the latter part of the rainy season. The coarser soil is pale coloured and generally richer in carbonates.

V. VEGETATION

1. General characters of the vegetation

The pioneer species which consolidates the soil against erosion in the area is *Capparis septaria*. On account of the thorns on the plant it also affords protection to the vegetation growing under it against grazing. As a result *Diospyros cordifolia* followed by a number of deciduous trees rapidly grow up to form a closed forest. Most of these and especially the two species named above are capable of regenerating from buds developing on their roots as they get exposed on erosion of the soil. These can therefore establish along with some annuals on the precipice also. Thus the ravines get completely covered with a thick mantle of forest which becomes quite impenetrable by the middle of the rainy season every year so effectively checking soil erosion indeed, at a time when its absence might be disastrous to the plateau.

With the dying of the annuals, slower growth of the perennials and indiscriminate grazing and removal of wood for fire in the following cold season the forest becomes thinner. The uppermost storey consisting of the deciduous trees opens up still further by the fall of the leaves in the beginning of the hot season. The forests of the ravines become poorer with the march of the dry seasons since the intensity of the biotic factors increases simultaneously with a gradual decline in the growth of the vegetation. Continued grazing and scraping of the ground vegetation prepare the plateau for a fresh assault by the monsoon erosion which has been shown to be severe in the earlier part of the rainy season.

2. Plant communities

The following plant communities have been recognised in this study. The species marked with an asterisk are either exclusively confined or more abundant in the sunny Ganges ravines. The notations used are:—*d*—dominant, *cd*—codominant, *a*—abundant, *f*—frequent, *o*—occasional, *r*—rare; *v* and *l* used as prefix signify 'very' and 'local':—

1. *Holoptelia*—*Albizia*—*Cordia* association

<i>Holoptelia integrifolia</i> , Planch.	<i>d</i>	<i>Feronia elephantum</i> , Correa.	<i>r</i>
<i>Albizia lebbek</i> , Benth.	<i>cd</i>	<i>Tamarindus indica</i> , L.	<i>r</i>
<i>Cordia myxa</i> , L.	<i>cd</i>	<i>Ficus religiosa</i> , L.	<i>r</i>
<i>Pongamia glabra</i> , Vent.	<i>o-f</i>	<i>Ehretia acuminata</i> , Br.	<i>vr</i>
<i>Melia Azadirachta</i> , L.	<i>o</i>	<i>Mitragyna parvifolia</i> , Korth.	<i>vr</i>
<i>Acacia leucophlaea</i> , Willd.	<i>o</i>		

2. Consociations of *Holoptelia integrifolia*, *Albizia lebbek* and *Cordia myxa*3. Societies of *Pongamia glabra* and *Acacia leucophlaea*4. *Capparis*—*Diospyros* associates

<i>Capparis sepiaria</i> , L.	<i>d</i>	* <i>Lantana indica</i> , Roxb.	<i>f</i>
<i>Diospyros cordifolia</i> , Roxb.	<i>cd</i>	<i>Cocculus villosus</i> , DC.	<i>r</i>
* <i>Capparis horrida</i> , L.	<i>o</i>	<i>Coccinia indica</i> , W. and A.	<i>o</i>
* <i>Clerodendron phlomidis</i> , L.	<i>o</i>	<i>Quamoclit pinnata</i> , Boj.	<i>o</i>
* <i>Abrus precatorius</i> , L.	<i>o</i>	<i>Rhynchosia minima</i> , DC.	<i>o</i>
<i>Abutilon indicum</i> , G. Don.	<i>o</i>	<i>Cardiospermum halicacabum</i> , L.	<i>r</i>
<i>A. graveolens</i> , W. and A.	<i>o</i>	<i>Melothria heterophylla</i> , Cogn.	

The climbers become more abundant during the rainy season.

5. Consociates of *Capparis sepiaria* and *Diospyros cordifolia*6. Associates of *Ficus glomerata*—*Pongamia glabra*

<i>Ficus glomerata</i> , Roxb.	<i>d</i>	<i>Ficus religiosa</i> , L.	<i>o</i>
<i>Pongamia glabra</i> , Vent.	<i>cd</i>	* <i>Dalbergia sissoo</i> , Roxb.	<i>r</i>

7. *Saccharum* consociates

<i>Saccharum munja</i> , Roxb.	<i>d</i>	<i>Desmostachya bipinnata</i> , Stapf.	<i>f-a</i>
<i>S. Ravennae</i> , L.	<i>f</i>	<i>Indigofera tinctoria</i> , L.	<i>o</i>
<i>Alhagi camelorum</i> , Fisch.	<i>a</i>		

8. A scrub colony

<i>Acacia arabica</i> , Willd.	<i>f</i>	<i>Phoenix sylvestris</i> , Roxb.	<i>f</i>
<i>Zizyphus jujuba</i> , Lamk.	<i>f</i>	<i>Streblus asper</i> , Lour.	<i>o</i>

9. Colonies and societies of herbs

(a) On precipice :

<i>Aerua scandens</i> , Wall.	<i>Linaria ramosissima</i> , Wall.
<i>Aristida adscensionis</i> , L.	<i>Lindenbergia urticaefolia</i> , Lehm.
<i>Cenchrus ciliaris</i> , L.	<i>Peristrophe bicalyculata</i> , Nees.
<i>Chloris virgata</i> , Sw.	<i>Pulicaria crispa</i> , Benth.
<i>Digitaria sanguinalis</i> , Scop.	

(b) On moderately eroded land :

Abutilon indicum, G. Don.
Aerua scandens, Wall.
Blepharis boerhaaviaefolia, Pers.
B. molluginifolia, Pers.
Desmostachya bipinnata, Stapf.
Dichanthium annulatum, Stapf.

Indigofera tinctoria, L.
Nepeta ruderalis, Ham.
Pulicaria crispa, Benth.
Pupalea lappacea, Moq.
Saccharum munja, Roxb.

(c) On open grounds :

Achyranthes aspera, L.
Blumea spp.
Boerhaavia diffusa, L.
† *Cassia occidentalis*, L.
† *C. tora*, L.
† *Crotalaria medicaginea*, Lamk.
Cynodon dactylon, Pers.
Cyperus rotundus, L.
Dichanthium annulatum, Stapf.
Digera arvensis, Forsk.
† *Digitaria sanguinalis*, Scop.

Euphorbia hirta, L.
E. prostrata, Ait.
E. thymifolia, L.
Indigofera ennaephylla, L.
Jatropha gossypifolia, L.
Justicia diffusa, Willd.
Ocimum canum, Sims.
Sida rhombifolia, L.
† *Urochloa reptans*, Stapf.
Vernonia cineria, Less.

(d) On shaded grounds :

Acalypha ciliata, Forsk.
A. indica, L.
Achyranthes aspera, L.
* *Anisomeles ovata*, R.
* *Barleria prionitis*, L.
Biophytum sensitivum, D. C.
Boerhaavia repanda, Willd.
† *Commelina benghalensis*, L.
† *Corchorus acutangularis*, Lam.
Desmodium gangeticum, DC.
Eleusine aegyptica, Desf.
Eragrostis tenella, Stapf.
Hyptis suaveolens, Poit.
Malvastrum tricuspidatum, A. Gray.
‡ *Nepeta ruderalis*, Ham.
‡ *Nicotiana tabacum*, L.
† *Oplismenus Burmanii*, Beauv.

Oxalis corniculata, L.
† *Paspalidium flavidum*, Stapf.
† *Peristrophe bicalyculata*, Nees.
Phyllanthus niruri, L.
† *Physalis minima*, L.
Ruellia prostrata, Poir.
R. tuberosa, L.
Rungia parviflora, Nees.
‡ *Salvia plebefa*, Br.
† *Setaria intermedia*, Roem. and Sch.
† *S. plicata*, T. Cooke.
† *S. rhachitricha*, T. Cooke.
Sida veronicaefolia, Lamk.
Solanum nigrum, L.
S. verhascifolium, L.
† *Triumfetta neglecta*, W. and A.
Vernonia cinerea, Less.

The species marked with † are found in the rainy season and those with ‡ come up in the cold season only.

(e) On annual deposits laid down by the river :

Alhagi camelorum, Fisch.
Alternanthera sessilis, Br.
A. paronychoides, Fort.
Argemone mexicana, L.
Celsia coromandelina, Wall.
* *Chrozophora Rottleri*, A. Juss.
Cochlearia flava, Ham.
Croton sparsiflorus, Morung.
Cynodon dactylon, Pers.
* *Datura alba*, Nees.
Euphorbia spp.

Gnaphalium spp.
Grangea maderaspatana, Poir.
* *Heliotropium ovalifolium*, Forsk.
* *Lantana indica*, Roxb.
Lippia nodiflora, Rich.
Mollugo hirta, Thunb.
Polygonum plebejum, Br.
Potentilla supina, L.
Rumex dentatus, L.
Veronica anagallis, L.
Xanthium strumarium, L.

3. Structure and distribution of the communities

The much eroded and grazed upper ravines bear the *Capparis-Diospyros* associates. The dominant species of the associates are ever-green thorny shrubs which grow upto a height of 10 to 20 feet covered with leaves from the base to the top and are usually infested with a large number of climbers. The community becomes closed in the narrower ravines and the gaps elsewhere are filled up by the ground vegetation which grows very dense during the rainy season when the taller herbs become continuous with the lower shoots of the dominant species. The plateau itself is locally covered by the consociates of *Capparis sepiaria* which, however, is too open due to the intensity of the biotic factors.

The forest association of *Holoptelia-Albizia-Cordia* comes up in the ravines where the *Diospyros-Capparis* associates has minimised grazing and erosion of soil. The dominant trees attain a height of 40 to 60 feet forming a closed canopy at the top which is penetrated by light only in April and May when the leaves are shed off. The second storey of this association consists of young trees and the associates and the consociates of *Capparis* and *Diospyros* on low ridges as these run under the forest canopy. The ridges originally separated the young ravines which have now fused on growing bigger and the neighbouring trees have overtopped them. The lower ravines which get inundated by the river during the rainy season have developed the *Ficus-Pongamia* associates and here societies of *Pongamia glabra* and *Acacia leucophlœa* generally line the association on the Barna side. Where the association is open and sand has been deposited at the bottom of the ravines fragments of a scrub colony of *Acacia arabica*, *Zizyphus jujuba* and *Phænix sylvestris* are often met with. They generally follow a consociate of *Saccharum*. These communities would undoubtedly show a better development on the sloping banks of the rivers but for the intense cultivation.

The development of the association is completely arrested at the top of the plateau on account of the biotic factors. There is a small and very open relict consociation of *Holoptelia integrifolia* in the north-east; the rest of the area is sprinkled with the consociates of *Capparis*.

The herbaceous layer of the association is composed of elements characteristic of situations exposed to erosion, sun and shade and those of the sandy river banks. They show marked seasonal aspects and have already been listed as forming colonies and societies.

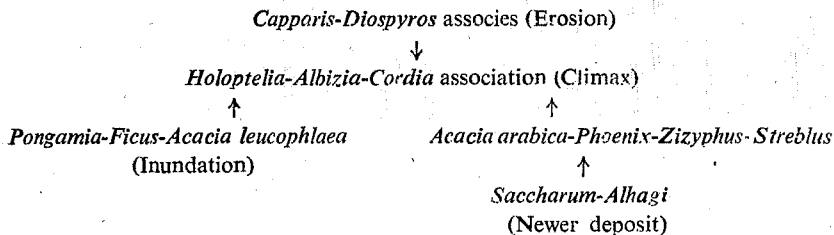
It will be seen that the stratification of the ravine forest association is chiefly on account of a corresponding layering of the soil. The tree layer is supported by the deeper old alluvium, the shrub layer of *Capparis-Diospyros* associates runs underneath on rough lands subjected to monsoon erosion and the ground vegetation is dependent chiefly on the surface soil. *Capparis sepiaria* and *Diospyros cordifolia* are indifferent to light conditions and since the community maintains its identity with the factor of erosion even under the tree layer it has

been regarded as an independent associates though by structure it forms here only a layer society of the association. Similarly the ground vegetation on the sand, in the lower ravines, has not much to do with the top layers. However, the societies and the colonies dependent on the shade have to be regarded as parts of the association.

The unstable precipice bears patchy colonies of herbs. This is gradually succeeded by the *Capparis-Diospyros* associates which hangs down from the ridge and the species root on the vertical earth. A landslide may rarely cut across the tree covered areas. On the Barna side *Pongamia glabra* and on the sunny Ganges side *Dalbergia sissoo* regenerate more quickly than the other species can do from buds developing on the exposed roots attached to the precipice.

4. Successional relationships

The plant communities are developmentally related as shown below :—



VI. DISCUSSION

The vegetation of the Rajghat ravines is nearer the climax of the Upper Gangetic Plain which has been described as a monsoon deciduous forest by Dudgeon (1920) and a tropical dry deciduous forest by Champion (1936). In this respect it is very different from the thorn-scrub type of vegetation consisting of species of *Acacia* or, on saline soils, *Butea frondosa* as is generally obtained in the ravines round about Benares. Erosion of soil and its low capacity for retaining moisture on account of rapid run off and poor plant cover are chiefly responsible for the existence of the thorn-scrub in such areas. But the Rajghat-ravines running down from the plateau and surrounded by the two perpetual rivers actually enjoy better humid conditions and here the old fertile alluvium is more retentive of moisture in spite of the rapid run off. The communities of *Capparis-Diospyros*, *Saccharum-Alhagi* and *Acacia-Phoenix-Zizyphus* have been shown to be largely dependent on the surface soils and these afford the necessary protection against grazing and thus lead to the development of the deciduous forest association which is sustained by the deeper old alluvium. This association is not large enough here to include many of the constituent species of the climax type as detailed by Champion (1936) for certain places in this province. But it seems to have a relict value fairly indicating that *Holoptelia integrifolia*, *Albizia lebbek* and *Cordia myxa* are the dominant species of the type for this area.

VII. SUMMARY

The development of the ravines and their vegetation have been described in relation to the environmental factors as obtained at the plateau of Rajghat.

Altogether nine types of plant communities have been recognised. Their structure, distribution and successional relationships are detailed and the nature of the climax vegetation is discussed.

VIII. ACKNOWLEDGMENT

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