

Study of floristic composition and systematic enumeration of newly introduced tree species of Bhopal, Madhya Pradesh, India

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Abstract

The present paper deals with change detection in tree diversity across natural and semi-natural vegetation types of Bhopal. A systematic enumeration of new tree species of Bhopal, Madhya Pradesh was made. There are 263 taxa belonging to 60 families were found within a land area of 90 km². Recently reported 70 tree species were enumerated. The nomenclature of taxa, information on popular name, common features, place of finding and habit of each taxa were provided.

Keywords: Diversity, enumeration, nomenclature, systematic, taxa

1. Introduction

The basic idea of evaluation of the floristic composition of any area is essential primary need for the study of any ecosystem. It is very necessary in the taxonomic field to assess and evaluate the floristic composition of any region time to time to find out the gradual changes. The conference for assessment of floristic diversity held at Kodaikanal in 1962 also recommended in this regard. It concerns that the flora of all main cities and their environments will be worked out. Mostly our most floras have all been published either in the last quarter of the twentieth century or earlier. But since then migrations and import of plants and biotic interference, have been changed the tree diversity of the most cities and urban settlements due to introduction of new species. In general tropical dry deciduous forests constitute very less diverse plant communities on earth. The effect of anthropogenic disturbances on species diversity is main issue that has engaged the attention of ecologists and taxonomists both from applied and theoretical and point of views (Stapanian *et al.* 1997) [16]. The factual studies of Hurd *et al.* (1971) [6], McNaughton (1977, 1985) [7, 8], Tilman (1988) [18], Frank & McNaughton (1991) [4], Tilman & Downing (1994) [17], also supported this hypothesis that ecosystems with rich species diversity are more resilient and stable to environmental disturbances than those, which have less species diversity. Collins *et al.* (1995) [3] argued that richness should be highest at moderate frequencies of disturbances when condition favors the competitive species and those which tolerate disturbances.

Recently many studies have reported major changes in sub-tropical forests, with shift and increase in plant species composition which favors fast-growing species over the slow-growing ones. These extensive alterations were credited to global environmental change, and result in dramatic shifts in composition of sub-tropical forest ecosystems. Desperate changes in land use pattern which associated with urbanization have resulted in an enormous impact on those fringe areas of human settlements where forests are situated. Recurrent tree species inventories, including detailed taxonomic identification, integrated with information on species traits, let a direct assessment of the relationship between changes in tree species composition.

Previously Oommachan explored angiosperm flora of Bhopal (1978) [11], since then floristic constitution of tree diversity is changed due to extensive plantation by Forest department, CPA (Capital Project Administration), Education department, Bhopal Development Authority, Municipal corporation and local residents. Therefore, the present study has been undertaken to find out newly introduced tree species and clear picture of their current status of tropical dry deciduous forest of Bhopal, Madhya Pradesh, India.

2. Materials & Methods

2.1 Study Area

The study site (23° 15' N latitude and 75° 24' E longitude; altitude 503 m above the mean sea level) is located at Bhopal, the capital of Madhya Pradesh. The forest type of Bhopal, Madhya Pradesh is tropical dry deciduous forest (Champion, H. G. & S. K. Seth, 1968) [2]. The forest is mainly dominated by *Tectona grandis* as main species in certain areas. Some other species like *Butea monosperma*, *Dalbergia sp.*, *Diospyros melanoxylon*, *Terminalia sp.*, *Lagerstroemia sp.*, *Zizyphus sp.*, are the co-dominants in these forests. In recent few year, the composition of plant species of this area is changed due to urbanization and avenue and shade tree plantation. Many plant species have become endangered due to overexploitation and several newly introduced species like *Cassia siamea*, *Peltophorum pterocarpum*, *Alstonia scholaris*, *Gliricidia maculata*, etc. are dominating as avenue and shade trees species in Bhopal. The climate of the study area is monsoonal with cool dry winter and warm moist summer. The mean minimum temperature ranged from 8.3 °C (January) to 27.5 °C (August), while the mean maximum temperature varied from 25.5 °C (January) to 42.3 °C (May). The mean annual rainfall is 1080 mm. During south east monsoon season maximum relative humidity is generally above 70%. During summer the relative humidity is less than 20%. Soils of the study area are mainly black cotton or laterite soil.

3. Methodology

The study was conducted during the year 2018-2020. Various part within this area were visited for species

enumeration during different seasons of flowering and fruiting. Species of various trees were collected, documented and identified with the help of Rao & Shastry's Flowering plants of Indore, M. P. (1964) ^[14], Indian trees (Brandis, D. 1971) ^[1], Flora of Bhopal (Oommachan, M. 1978) ^[11], Trees of Andhra Pradesh, India (Pullaiah, T. & S.S. Rani, 1999) ^[13], Flora of M.P. Vol. I (Verma *et al.* 1993) ^[19], Flora of M.P. Vol. II (Mudgal *et al.* 1997) ^[9], Flora of M.P. Vol. III (Singh *et al.* 2001) ^[15], and Trees of India (Mukherjee, P. 2008) ^[10]. The Angiosperms, Gymnosperms, & Pteridophytes species were systematically arranged into families according to Bentham and Hooker's system of classification. All new reported taxa were arranged alphabetically under the families of Dicotyledon, Monocotyledon, Gymnosperm and Pteridophyte. Botanical name, with local name of species provided in parenthesis, information on habit of species, place of finding, common features and time of flowering are given.

4. Results and Discussion

4.1 Systematic Enumeration of New tree species of Bhopal Angiosperms Magnoliopsida (Dicotyledons)

Annaceae

1. *Cananga odorata* (Lam.) Hook.f. & Thomson. (Ylang-ylang plant) Small tree, Old M.L.B.College, flowers greenish yellow, curly like a sea star, flowering: Feb.-March.

Bixaceae

2. *Bixa orellana* L. (Sindur tree) Small tree, Kolar Park, flowers white or rosy, flowering: July-August.

Sterculiaceae

3. *Sterculia villosa* Roxb. Medium tree, Ekant Park, flowers unisexual, yellow or pinkish, flowering: Jan-March.

Burseraceae

4. *Commiphora wightii* Arnott. (Gugal) Small tree, Kolar Park, leaves are trifoliolate, pinnae 3, flowers green-yellow, flowering: Feb.-March.

Anacardiaceae

5. *Lannea grandis* Engl. (Odina wodier Roxb.) Medium tree, Kolar Park, Bark ash colored, Flowers crowded cymose panicles, yellow, flowering: Mar.-April.

Fabaceae

6. *Acacia concinna* (Willd.) DC. (Shikakai) Small tree, Misrod, flowers yellow, globose heads, flowering: July-August.
7. *Acacia farnesiana* (L.) Willd. (Gandi babool) Small tree, Govindpura C-Sec., pod cylindrical hooked with bad odor, flowers yellow, flowering: Aug-October.
8. *Acacia ferruginea* DC. Prodr. (Safed kher) Medium tree, Kolar Park, Leaf rachis not pubescent, flowers white, flowering: July-August.
9. *Acacia senegal* (L.) Willd. (Persian acacia) Small tree, B.U.Campus, prickles usually in 3, flowers white, flowering: July-September.
10. *Acacia tortilis* (Forssk.) Hayne. (Israeli babool) Small tree, Damkheda, long white prickles, flowers small white heads, flowering: Feb.-march.
11. *Albizia amara* Roxb. Medium tree, Kolar Park, smooth green bark, flowers greenish-white, pod greyish brown, flowering: March-May.
12. *Albizia julibrissin* Durazz. (Pink siris) Small tree, Ekant Park, flowers white or pink with a white base, Flowering: throughout the summer.

13. *Bauhinia recemosa* Lamk. (Wild kachnar) Small tree, B.U.Campus, leaves smaller than other bauhinia, flowers white and pink, flowering: April-May.
14. *Bauhinia tomentosa* L. (Yellow Bauhinia) Small tree, Beema kunj, flowers; bright yellow, flowering: Dec.-March.
15. *Calliandra haematocephala* Hassk. (Powder puff) Small tree, Itwara, flower pink with powder-puff-like balls of conspicuous dark crimson stamens, flowering: March-April.
16. *Cassia didymobotrya* Fresen. (Candle cassia) Small tree, E-7 Arera colony, flowers golden-yellow, flowering: Jan.-February.
17. *Dichrostachous cinnrea* Linn. Small tree, Arera hill, apical buds of axillary shoots ending into sharp spines, flowers pink, flowering: July-August.
18. *Leucaena leucocephala* Lamk. (Subabool) Large tree, Nutan College Campus, flower white globose heads, flowering: Nov.-March.
19. *Milletia pinnata* (Vilayati Karanj) Medium tree, Nootan College Campus, flowers blue like *pongamia*, flowering: Feb.-March.
20. *Pterocarpus marsupium* Roxb. (Beejasal) Large tree, way to Kolar Dam, flowers yellow, flowering: July-August.
21. *Senna polyphylla* (Jacq.) H.S. Irwin & Barneby (Desert cassia) Small tree, Shahpura C-sec., flowers are yellow, axillary racemes of mostly two flowers, flowering: Feb-March.

Combretaceae

22. *Terminalia alata* Heyne ex Roth. (Saja) Large tree, Beema kunj, leaves long elliptic, flowers greenish yellow, flowering: Apr.-May.
23. *Terminalia chebula* Retz. (Harra) Large tree, Ekant Park, flowers creamy white, flowering: Apr.-May.

Myrtaceae

24. *Eugenia hemispherica* Wight. Large tree, Ekant Park, flowers white fragrant panicle cymes, flowering: May-June.
25. *Eugenia Heyneana* Wall. (Choti jamun) Small tree, Govindpura, Flowers sessile, white in compound trichotomous cymes, flowering: April-May.
26. *Eugenia jambos* Linn. Small tree, Kolar Park, flowers large white, flowering: Feb.-March.
27. *Syzygium aromaticum* (L.) Merr. & Perry (*Laung*) Medium tree, Kolar Park, Flowers, white scented, flowering: April-May.

Barringtoniaceae

28. *Barringtonia acutangula* (L.) Gaertn. Small tree, Ekant Park, flowers in slender pendulous, red, flowering: Feb-March.

Lecythidaceae

29. *Couroupita guianensis* Aubl. (Cannonball tree) Large tree, Old M.L.B. College, flowers cauliflorous; yellow, reddish, flowering: May-June.

Rubiaceae

30. *Coffia arabica* L. (Coffee tree) Small tree, Ekant Park, flowers white solitary in pairs, flowering: Feb.-March.
31. *Gardinia gummifera* L.f. (Dikamali) Small tree, Ekant Park, flowers white corolla tube up to 6 cm long, flowering: March-April.
32. *Haldina cardifolia* Roxb. (Haldu) Large tree, Kolar road forest, flowers heads of yellow color, flowering: June-July.

33. *Morind pubescens* Sm. (Aal) Small tree, Railway colony E-8, flowers heads of white color, flowering: March.
 34. *Wendlandia tinctoria* Roxb. Small tree, Kolar Park, flowers small white sessile, flowering: Jan.-Feb.

Oleaceae

35. *Schrebera swietenoides* Roxb. (Mokha) Medium tree, Kolar Park, flowers creamy white, capsules drooping verrucose, flowering: March.

Apocynaceae

36. *Alstonia scholaris* Brown. (Devil tree) Medium tree, common, flowers greenish yellow, flowering: Dec.-Jan.
 37. *Plumeria alba* L. (Champa) Small tree, Kolar Park, flowers white with yellowish tinge, flowering: Whole the year.

Loganiaceae

38. *Strychnos nuxvomica* L. (Kuchla) Medium tree, Ekant Park, sometimes with axillary thorns, flowers greenish yellow, flowering: Mar.-April.

Bignoniaceae

39. *Dolichandrone falcata* Seem. (Mersingh) Medium tree, VIP road, flowers white terminal corymbose, flowering: Mar.-April.
 40. *Oroxylum indicum* L. Large tree, Ekant Park, flowers solitary dirty violet, flowering: June.
 41. *Steoreospermum suaveolens* L.f. (Katori) Large tree, Kolar Park, flowers panicles dull purple with yellow, flowering: Mar.-April.
 42. *Tabebuia argentea* (Bureau & K. Schum.) Britton Medium tree, 1100 Quaters, flowers yellow campanulate, flowering: Feb.-March.

Lauraceae

43. *Cinnamomum camphora* (L.) Sieb. (Kapoor tree) Medium tree, Ekant Park, flowers small white, flowering: in spring.
 44. *Cinnamomum tamola* T.Nees & Eberm. (Tejpat tree) Medium tree, Ekant Park, flowers white in 5-10 cm long penicles, flowering: July.
 45. *Cinnamomum zeylenicum* Breyn. (Dalchini tree) Medium tree, Ekant Park, flowers in axillary, lax panicles, flowering: Nov.-December.
 46. *Litsea glutinosa* (L.) Large tree, Ekant Park, flowers white in large compound umbels, flowering: Aug.-September.

Euphorbiaceae

47. *Antidesma diandrum* Roth. Small tree, Sarvadharm C-sector, flowers white pedicellate recemose, flowering: Mar.-April.
 48. *Bischofia javanica* Blume. Large tree, Bhoj Uni. forest, flowers small greenish yellow, flowering: Mar.-April.
 49. *Bridellia retusa* Spreng. (Kasai) Medium tree, Ekant Park, spinous when young, flowers greenish yellow, flowering: April.
 50. *Glochidion zylenicum* Gaertn. Medium tree, Raisen road forest, flowers shortly pedicellate greenish, flowering: March.
 51. *Trema orientalis* (L.) Blume Small tree, Ekant Park, Flowers small, green or greenish-white, unisexual, flowering: March-April.

Moraceae

52. *Ficus arnotianae* Miq. Large tree, Ekant Park, flowers receptacle in axillary pairs, flowering: Feb.-March.
 53. *Ficus benjamina* L. Large tree, Ekant Park, leaves waxy curved, flowers small receptacles on drooping branches, flowering: March-April.

54. *Ficus elastica* Roxb. (Rubber tree) Medium tree, Shahpura Lake, broad shiny oval leaves 10-35 centimeters.

55. *Ficus krishnae* C. DC. (Krishna vat) Medium tree, Ekant Park, leaves acute at both apex and base, Flowers orange receptacles, flowering March-April.

56. *Ficus Panda* (Japani peepal) large tree, Ekant Park, leaves are lanceolate, shiny, flowers, small receptacles, green-yellow, flowering: Feb.-March.

57. *Ficus roxburghii* Wall. (timla) Small tree, Administration academy campus, flowers unisexual; inflorescence hypanthodium, flowering: March-April.

Salicaceae

58. *Salix alba* L. (White willow) large tree, flowers catkins, male, female on separate plant, creamy yellow flowering: March-April.

Liliopsida (Monocotyledons)**Aracaceae**

59. *Borrassus flabellifer* Linn. (Fan Palm) Large tree, E-7 Arera colony, leaves flabelliform, leaflets 60-80, flowering: Dec.-Jan.

60. *Elaeis guianensis* J. Gaertn (Palm oil tree) Small tree, Ekant Park, male and female flowers in separate clusters, but on same tree.

Gymnosperm**Pinaceae**

61. *Pinus longifolia* Salisb. (Chir) Large tree, Common in gardens, leaves needle like, female cone large, male cone at tip of branches.

Araucariaceae

62. *Agathis robusta* (C.Moore ex F.Muell.) Bailey (Pauri pine) large tree, Nootan College, seed cones are globose, 8-13 cm diameter, and mature in 18-20 months after pollination, Maturity: July-September.

63. *Araucaria araucana* (Molina) K. Koch (Monkey-puzzle) Large tree, Common in gardens, horizontal, spreading branches grow in whorls, dioecious.

64. *Thuja orientalis* L. (Vidya) Large tree, Common in gardens, fan-like branches and scaly leaves, monoecious and ornamentally insignificant in April.

Cupressaceae

65. *Cupressus torulosa* D.Don Large tree, Common in gardens, Crown large oval to broadly conical, male cone subglobular, female cone globose or elliptic, Cones appear in Feb.-March.

66. *Juniperus communis* L. Small tree, Common in gardens, needle-like leaves in whorls of three, dioecious, seed cones are berry-like.

Podocarpaceae

67. *Podocarpus macrophyllus* (Thunb.) Sweet Medium tree, Mayo Park, leaves are strap-shaped, cones are borne on a short stem, and have 2-4 scales.

Cycadaceae

68. *Cycas revoluta* Thunb. (sago cycad) Small tree, Common in gardens, leaves are a deep semiglossy green and about 50-150 cm, seeds bright orange.

69. *Cycas circinalis* L. (Queen Sago) Small tree, Common in gardens, Leaves bright green, semi glossy, 150-250 cm long, Seeds sub globose, 25-38 mm long.

Pteridophyte**Cyatheaceae**

70. *Cyathea cooperi* (W. J. Hooker ex F. von Mueller) Domin. (Tree Fern) Small tree, Railway colony E-8, crown is widely spread and the light green in color.

4.2 Diversity of Tree species

A total of 263 tree species belonging to 60 families were recorded in present study. Among families, Fabaceae (55 species), Moraceae (19 species), Euphorbiaceae (14 species), Myrtaceae (11 species), Bignoniaceae (11 species), Rubiaceae (11 species), Combretaceae (9 species), Aracaceae (9 species), Apocynaceae (7 species), Rutaceae (7 species) the species diversity was maximum. Anacardiaceae and Sterculiaceae are represented by 6 species each, Annonaceae, Bombacaceae, Rosaceae, Ehretiaceae and Sapindaceae by 5 species. Whereas 5 families (Lythraceae, Meliaceae, Verbenaceae, Sapotaceae, Lauraceae) have four species each, 2 families (Tiliaceae, Cupressaceae) have three species, 11 families have two species each and the remaining 25 families were monospecific (Table 1).

Table 1. Number of previous, present and new reported tree species in different families

Family	Previous Species	Present Species	New Species
Fabaceae	39	55	16
Moraceae	13	19	6
Euphorbiaceae	9	14	5
Bignoniaceae	7	11	4
Myrtaceae	7	11	4
Rubiaceae	6	11	5
Aracaceae	7	9	2
Combretaceae	7	9	2
Apocynaceae	5	7	2
Rutaceae	7	7	-
Anacardiaceae	5	6	1
Bombacaceae	5	5	-
Sterculiaceae	5	6	1
Annonaceae	4	5	1
Ehretiaceae	5	5	-
Rosaceae	5	5	-
Sapindaceae	5	5	-
Lauraceae	-	4	4
Lythraceae	4	4	-
Meliaceae	4	4	-
Sapotaceae	4	4	-
Verbenaceae	4	4	-
Cupressaceae	-	3	3
Tiliaceae	3	3	-
Araucariaceae	-	2	2
Barringtoniaceae	1	2	1
Bursaraceae	1	2	1
Celastraceae	2	2	-
Cycadaceae	-	2	2
Malvaceae	2	2	-
Oleaceae	1	2	1
Poaceae	2	2	-
Rhamnaceae	2	2	-
Salicaceae	1	2	1
Simaroubaceae	2	2	-
Others	19	25	6
Total	193	263	70

When compare it with earlier recorded flora of Bhopal in which 193 tree species enumerated belonging to 54 families, but in present study 263 tree species belonging to 60 families recorded. Further 70 new tree species, out of which 60 species belonging to 20 Angiosperm families, 9 species belonging to 5 Gymnosperm families and 1 Pteridophyte species were reported.

Dominant forest species are mainly *Tectona grandis*, *Terminalia sp.*, *Butea monosperma*, *Anogeissus sp.*, *Buchanania lanzan*, etc. While *Diospyros melanoxylon* and *Maduca latifolia* shows patchy distribution. *Helicteris isora* and *Gymnosporia rothiana* constitute the forest undergrowth. Scrub jungle is dominated by thorny species such as, *Acacia leucophloea*, *Acacia arabica*, *Zizyphus jujuba*, etc. On the bank of ravines *Pongamia pinnata* and *Syzygium cumini* are predominantly seen.

Mainly popular plantation and habitation dwelling trees are shady and exotic include Sayami Cassia (*Cassia siamea*), Copper pod (*Peltophorum pterocarpum*), Gulmohar (*Delonix regia*), Asoka (*Polyalthia longifolia*), Rain tree (*Samanea saman*), Bottle palm (*Roystonea regia*), Fountain tulip (*Spathodea companulata*), Silver Oak (*Grevillea robusta*), Devil tree (*Alstonia scholaris*) Benjamin fig (*Ficus benjamina*), Neelmohor (*Jacaranda mimisaefolia*), Cork tree (*Millingtonia hortensis*) etc. Dominating tree plantations are particularly on forest department and municipal corporation land include *Leucaena* and *Dalbergia Eucalyptus*, and *Gliricidia sepam*. Unfortunately, the increase in populations of most of these ornamental, exotic and avenue trees has been at the cost of local and fruit bearing tree species with decreasing populations over the last few years. These include Sahajana (*Moringa oleifera*), Neem (*Azadirachta indica*), Mango (*Mangifera indica*), Jackfruit (*Artocarpus heterophyllus*), Jamun (*Syzygium cumini*), Guava (*Psidium guajava*), Peepal (*Ficus religiosa*), Banyan (*Ficus benghalensis*) and Wild fig (*Ficus glomerata*). Species like the *Ficus* varieties were common as avenue and habitation trees earlier. Guava, Mango etc. were common in orchards along city fringes but now encroached by housing colonies. The thorn forest along with river banks dominated by *Acacia nilotica* and *Acacia leucophloea* trees are all cut and encroached, also erased stretches of Wild date palm (*Phoenix sylvestris*) the study area.

Our finding of studies related to tree species dissemination and their changes are parallel those as reported previously by Gadgil and Parthasarathy (1977)^[5] for Bangalore city and Patwardhan and Gandhe (2001)^[12] for Tree diversity of Pune urban area. These increase in the number of tree species is due to plantation of large number of trees for the purpose of shade and avenue trees by Forest and other department and local people. Result of our study indicates that diversity of plant species of any area will be increase if new species planted and conserve the existing species. But it is important to avoid fast growing species specially in forest plantation and must include local species along with RET species. Working as Forest Extension Officer in Forest Department author initiates work on that aspect and planted many RET and *Ficus* species in last two year which also enhance diversity of tree species of Bhopal in future.

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