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# FLORAL DIVERSITY IN VADODARA GARDENS, GUJARAT, INDIA

Dhara R. SHAH, Deepa J. GAVALI*

Gujarat Ecology Society, Synergy House, Subhanpura, Vadodara – 390023, Gujarat, India

***Abstract***

*Garden biodiversity is an integral part of the urban ecosystem and play an important role in improving green infrastructure and aid in climate change adaptations. Little research is available on the floral diversity of the parks and gardens. The present study is an attempt to document the floral diversity of 77 gardens in Vadodara city and elucidate trends based on the size of the gardens. Study indicated presence of 217 species belonging to 72 families from the gardens of Vadodara city. The floristic data revealed that around 53% of the species represented indigenous species and 47% belonged to exotic species. Paper concluded that diversity is more in the small gardens as compared to large sized garden, where plantation of few species in undertaken. Species suitable to the semi-arid climate with low water requirement dominated the gardens indicative of better management practices and adapt to climate change.*

***Keywords:*** *Garden; Urban ecosystem; Exotic species; Plant Diversity, Gujarat;*

## Introduction

Parks and gardens are an important part of urban ecology, and this supports the ecological integrity of cities and protects the health of the urban dwellers. City parks and open space improve our physical and psychological health, strengthen our communities, and make our cities and neighbourhoods more attractive places to live and work. Green spaces keep the temperature low, filter air, remove pollutants, attenuate noise and replenish ground water [1-2]. Garden biodiversity can play a key role in improving green infrastructure, with positive effects for human health and climate change adaptation. Furthermore, also urban temperature: green spaces mitigate the effects of extreme heat and cold. They support human health by easing stress and providing physical exercise [3]. Urban planners believed the parks would improve public health and relieve the stresses of urban life. Green spaces in urban areas provide substantial environmental benefits [4].

Trees in urban areas reduce air pollution by absorbing certain airborne pollutants from the atmosphere [5]. Trees also act as natural air conditioners to help keep cities cooler, mitigating the effects of artificial construction. The evaporation from a single large tree can produce the cooling effect of ten room-size air conditioners operating 24 hours a day. Green cover and urban forests can moderate temperature by providing shade and cooling an area, thus helping reduce the risk of heat-related illnesses for city dwellers [6-8].

The U.S. Forest Service calculated that over a 50-year lifetime one tree generates $31,250 worth of oxygen, provides $62,000 worth of air pollution control, recycles $37,500 worth of water, and controls $31,250 worth of soil erosion. In New York City, for example,

* Corresponding author: deepagavali@yahoo.com

nearly half of the city's 59 community board districts have less than 1.5 acres of parkland per 1,000 residents. In Atlanta, for example, parkland covers only 3.8 percent of the city's area [7]. US and Chinese cities have developed innovative ways to create new green space. Urban green space projects need more integrative sustainability policies to protect communities [9].

Greater attention requires to be paid to the selection of trees in cities, not just with a view to easy maintenance, as is currently the case, but to select an appropriate mix of trees that supports biodiversity and maximizes environmental and ecosystem services [10].

Little research or attention is paid to the parks and gardens, making it difficult to plan strategies for urban conservation [11-13]. Ample research is available on the gardens associated with the National Parks, but few studies conducted in the urban parks and gardens [12-17]. In India some efforts to document biodiversity of parks and gardens is done [18]. There are over 2500 botanic gardens in 150 countries across the world holding over 6 million accessions of living plants representing around 80,000 species [19], as well as 250,000 seed bank accessions [20]. In general, botanical gardens focus on conserving the inter-specific diversity of flora and thus, tend to maintain a large number of species with relatively few accessions for each species. In its country report, China indicated that it had 170 botanical gardens and India reported 150 [19-20]. Vadodara City has better green cover standing next to Gandhinagar [21].

Vadodara City has one of the oldest and largest gardens, Sayajibaug covering an area of 64ha. But there is hardly any survey to document the floristic diversity and relate the same with management of the parks. This study will thus provide important information on the biodiversity of parks in this little researched.

## Material and Methods

Vadodara lies between 22°18'00''N and 73°12'01'E longitude. River Vishwamitri passes through the city-dividing city into eastern and western part. There is total number of 77 gardens within the city. The present study was undertaken in 30 gardens, which were of substantial size and managed well. The gardens were categorized into three categories; category 1 included the gardens that were of size ≤ 1ha, category 2 ranged from 1.1ha to 5ha, category 3 included garden above 5ha. The distribution of different gardens within the city showed 16 gardens in category 1, 11 gardens in category 2, and only two gardens in category 3 (Fig. 1).

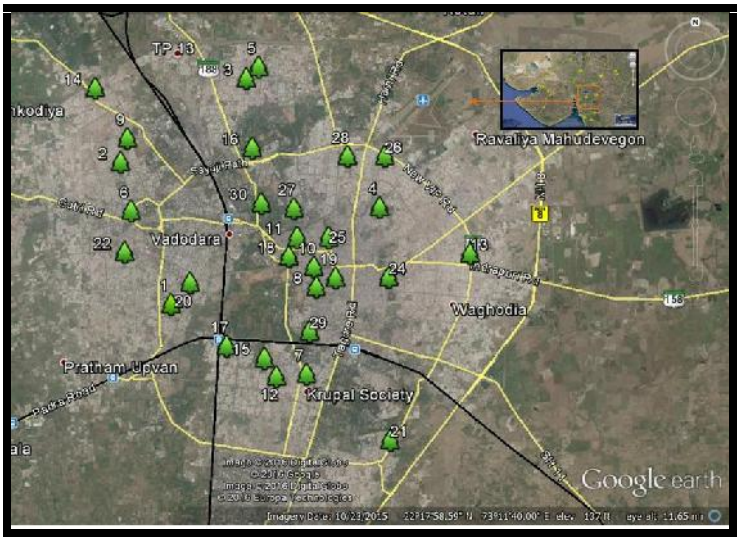


**Fig. 1.** Map of the study area

Survey of each garden was taken and all the species occurring within the garden was noted down. Standard reference was used for identification of the species [21]. In case of new plants digital photographs were taken, and the plants were later identified in the lab using various manuals. The species were then grouped based on habitat into trees, shrubs, herbs, grasses and climbers.

## Results and discussion

A total number of 217 species belonging to 72 families were reported from the gardens of Vadodara city (Table 1). Bogor botanical garden has been home to various species, 1349 rare plants, 255 trees over a century old, 9000 species of orchids, 216 species of ants, 96 species of butterflies, 35 species of birds [22].

**Table 1.** List of botanical name of plant species in the gardens.

| List of Garden's Flora | | | | | | | |
|---|---|---|---|---|---|---|---|
| No. | Botanical Name | No. | Botanical Name | No. | Botanical Name | No. | Botanical Name |
| 1 | *Bougainvillea* | 55 | *Canna spp.* | 109 | *Anthocephalus chinensis* | 163 | *Manihot esculenta* |
| 2 | *Clitoria ternatea* | 56 | *Carissa congesta* | 110 | *Areca catechu* | 164 | *Manilkara hexandra* |
| 3 | *Combretum rotundifolium* | 57 | *Catharanthus roseus* | 111 | *Azadirachta indica* | 165 | *Manilkara zapota* |
| 4 | *Epipremnum aureum* | 58 | *Cestrum nocturnum* | 112 | *Bauhinia monandra* | 166 | *Melia azedarach* |
| 5 | *Ipomoea marginata* | 59 | *Codiaeum variegatum* | 113 | *Bauhinia purpurea* | 167 | Michelia champaca |
| 6 | *Jacquemontia pentanthos* | 60 | *Cordyline terminalis* | 114 | Bauhinia x blakeana | 168 | Miliusa tomentosa |
| 7 | *Monstera deliciosa* | 61 | *Crinum asiaticum* | 115 | *Bergera koenigii* | 169 | *Mimusops Elengi* |
| 8 | *Parthenocissus quinquefolia* | 62 | *Cycas circinalis* | 116 | *Bismarckia nobilis* | 170 | *Mitragyna parvifolia* |
| 9 | *Parthenocissus tricuspidata* | 63 | *Dieffenbachia amoena* | 117 | *Bixa orellana* | 171 | *Moringa oleifera* |
| 10 | *Petrea volubilis* | 64 | *Dracaena reflexa* | 118 | Bombax ceiba | 172 | *Morus alba* |
| 11 | *Pyrostegia venusta* | 65 | *Duranta erecta* | 119 | *Borassus flabellifer* | 173 | *Morus Bomcycis* |
| 12 | *Quisqualis indica* | 66 | *Euphorbia cooperi* | 120 | *Caesalpinia sappan* | 174 | *Murraya paniculata* |
| 13 | *Artemisia vulgaris* | 67 | *Euphorbia cyathophora* | 121 | *Callistemon citrinus* | 175 | *Myristica fragrans* |
| 14 | *Cynadon dactylon* | 68 | *Euphorbia leucocephala* | 122 | *Callistemon viminalis* | 176 | *Neolamarckia cadamba* |
| 15 | *Agave americana* | 69 | *Euphorbia neriifolia* | 123 | *Capparis decidua* | 177 | *Nyctanthes arbor-tristis* |
| 16 | *Aloe maculata* | 70 | *Ficus elastica* | 124 | *Carica papaya* | 178 | *Pandanus odoratissimus* |
| 17 | *Anagallis arvensis ssp. foemina* | 71 | *Ficus pumila* | 125 | *Caryota urens* | 179 | *Parkia biglandulosa* |
| 18 | *Anemone coronaria* | 72 | *Galphimia glauca* | 126 | *Casearia tomentosa* | 180 | *Peltophorum pterocarpum* |
| 19 | *Bambusa balcooa* | 73 | *Gardenia jasminoides* | 127 | *Cassia fistula* | 181 | *Phoenix dactylifera* |
| 20 | *Bambusa bambos* | 74 | *Hamelia patens* | 128 | *Cassia grandis* | 182 | *Phoenix sylvestris* |
| 21 | *Bambusa tuldoides Munro* | 75 | *Hemigraphis colorata* | 129 | *Cassia roxburghii* | 183 | *Phyllanthus emblica* |
| 22 | *Bambusa vulgaris* | 76 | *Hibiscus rosa-sinensis* | 130 | *Chloroxylon swietenia* | 184 | *Pithecellobium dulce* |
| 23 | *Brachycome Iberidifolia* | 77 | *Ixora coccinea* | 131 | *Citrus aurantifolia* | 185 | *Platycladus orientalis* |
| 24 | *Caladium bicolor* | 78 | *Jasminum multiflorum* | 132 | *Cocos nucifera* | 186 | *Plumeria alba* |
| 25 | *Casuarina equisetifolia* | 79 | *Jasminum sambac* | 133 | *Commiphora wightii* | 187 | *Plumeria obtusa* |
| 26 | *Coreopsis tinctoria* | 80 | *Jatropha integerrima* | 134 | *Cordia dichotoma* | 188 | *Plumeria rubra* |
| 27 | *Dorotheanthus bellidiformis* | 81 | *Kerria japonica 'Pleniflora'* | 135 | *Cordia sebestena* | 189 | *Polyalthia longifolia* |
| 28 | *Eleusine indica* | 82 | *Lantana camara var. aculeata* | 136 | *Cordia subcordata* | 190 | *Pongamia pinnata* |
| 29 | *Euphorbia prostrata* | 83 | *Malvaviscus penduliflorus* | 137 | *Corymbia citriodora* | 191 | *Psidium guajava* |
| 30 | *Freesia spp.* | 84 | *Mussaenda erythrophylla* | 138 | *Couroupita guianensis* | 192 | *Ravenala madagascariensis* |
| 31 | *Gerbera jamesonii* | 85 | *Nerium oleander* | 139 | *Cycas revoluta* | 193 | *Roystonea regia* |
| 32 | *Glandularia pulchella* | 86 | *Nymphaea mexicana* | 140 | *Cyrtostachys renda* | 194 | *Salvadora oleoides* |
| 33 | *Helianthus annuus* | 87 | *Nymphaea pubescens* | 141 | *Dalbergia lanceolaria ssp. lanceolaria* | 195 | *Santalum album* |
| 34 | *Hymenocallis littoralis* | 88 | *Pandanus sanderi* | 142 | *Dalbergia latifolia* | 196 | *Sapindus emarginatus* |
| 35 | *Iberis amara* | 89 | *Pentas lanceolata* | 143 | *Delonix regia* | 197 | *Sapindus trifoliatus* |
| 36 | *Ocimum tenuiflorum* | 90 | *Plectranthus scutellarioides* | 144 | *Dillenia indica* | 198 | *Scaevola taccada* |
| 37 | *Opuntia cochenillifera* | 91 | *Polyscias fruticosa* | 145 | *Drypetes roxburghii* | 199 | *Schizolobium* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | *parahyba* |
| 38 | *Papaver bracteatum* | 92 | *Polyscias balfouriana* | 146 | *Dypsis lutescens* | 200 | *Senna spectabilis* |
| 39 | *Pittosporum tenuifolium* | 93 | *Rosa* | 147 | *Elaeis guineensis* | 201 | *Senna surattensis* |
| 40 | *Sansevieria trifasciata* | 94 | *Rosa 'Happy Wanderer'* | 148 | *Ficus benghalensis* | 202 | *Sesbania Sesban var. picta* |
| 41 | *Symphyotrichum novi-belgii* | 95 | *Rosa 'Summer Snow'* | 149 | *Ficus hispida* | 203 | *Spathodea campanulata* |
| 42 | *Tanacetum cinerariifolium* | 96 | *Rosa spp.* | 150 | *Ficus racemosa* | 204 | *Sterculia alata* |
| 43 | *Acalypha chamaedrifolia* | 97 | *Sansevieria cylindrica* | 151 | *Ficus religiosa* | 205 | *Sterculia foetida* |
| 44 | *Acalypha wilkesiana* | 98 | *Tabernaemontana divaricata* | 152 | *Gmelina arborea* | 206 | *Sterculia guttata* |
| 45 | *Adenium obesum* | 99 | *Tabernaemontana rostrata* | 153 | *Haldina cordifolia* | 207 | *Swietenia macrophylla* |
| 46 | *Aloe barbadensis* | 100 | *Tagetes erecta* | 154 | *Hippomane mancinella* | 208 | *Syzygium cumini* |
| 47 | *Alstonia venenata* | 101 | *Thunbergia erecta* | 155 | *Holoptelea integrifolia* | 209 | *Tabebuia aurea* |
| 48 | *Alternanthera brasiliana* | 102 | *Tradescantia spathacea* | 156 | *Hyophorbe lagenicaulis* | 210 | *Tabebuia pallida* |
| 49 | *Barleria prionitis* | 103 | *Turnera ulmifolia* | 157 | *Hyphaene indica* | 211 | *Tabebuia rosea* |
| 50 | *Cajanus cajan* | 104 | *Aegle Marmelos* | 158 | *Jacaranda mimosifolia* | 212 | *Tamarindus indica* |
| 51 | *Calendula officinalis* | 105 | *Alstonia scholaris* | 159 | *Lannea coromandelica* | 213 | *Tecoma castanifolia* |
| 52 | *Calliandra emarginata* | 106 | *Annona reticulata* | 160 | *Livistona chinensis* | 214 | *Tecoma stans* |
| 53 | *Calliandra haematocephala* | 107 | *Annona squamosa* | 161 | *Madhuca longifolia var. latifolia* | 215 | *Tectona grandis* |
| 54 | *Calotropis procera* | 108 | *Anogeissus sericea var.sericea* | 162 | *Mangifera indica* | 216 | *Thevetia peruviana* |
| | | | | | | 217 | *Ziziphus mauritiana* |

Among all the 72 families recorded, Arecaceae was found to be the most abundant with representation of 14 species followed by Caesalpiniaceae family (13 species), Apocynaceae (12 species) and Euphorbiaceae (11 species) (Table 2). Arecaceae family includes the palm trees, with distinguishing characteristics of large, compound, evergreen leaves arranged at the top of an unbranched stem. Due to its straight growth with low canopy cover, it is preferred in the gardens for their artistic feature.

**Table 2.** Representation of various families in the gardens

| Family | No. of species |
|---|---|
| Arecaceae | 14 |
| Caesalpiniaceae | 13 |
| Apocynaceae | 12 |
| Euphorbiaceae | 11 |
| Asteraceae, Rubiaceae | 9 |
| Bignoniaceae, Moraceae | 8 |
| Fabaceae, Poaceae, Verbenaceae | 6 |
| Myrtaceae, Rosaceae, Rutaceae | 5 |
| Annonaceae, Araceae, Mimosaceae, Sapotaceae | 4 |
| Acanthaceae, Agavaceae, Boraginaceae, Combretaceae, Meliaceae, Oleaceae, Sterculiaceae | 3 |
| Cycadaceae, Amaryllidaceae, Anacardiaceae, Araliaceae, Asphodelaceae, Convolvulaceae, Lamiaceae, Malvaceae, Nymphaeaceae, Pandanaceae, Ruscaceae, Sapindaceae, Vitaceae | 2 |
| Aizoaceae, Amaranthaceae, Asclepiadaceae, Bixaceae, Bombacaceae, Brassicaceae, Burseraceae, Cactaceae, Cannaceae, Capparaceae, Caricaceae, Casuarinaceae, Commelinaceae, Cupressaceae, Dilleniaceae, Goodeniaceae, Iridaceae, Lecythidaceae, Magnoliaceae, Malpighiaceae, Moringaceae, Myristicaceae, Myrsinaceae, Nyctaginaceae, Papaveraceae, Passifloraceae, Phyllanthaceae, Pittosporaceae, Putranjivaceae, Ranunculaceae, Rhamnaceae, Salicaceae, Salvadoraceae, Santalaceae, Solanaceae, Strelitziaceae, Ulmaceae | 1 |

The floristic data revealed that around 53% of the species represented indigenous species and 47% belonged to exotic species. The percentage of exotic was low, but better compared to gardens in Bangalore city, where 65% of the trees belonged to introduced species [23]. In study of gardens in Potsdam, the proportion of indigenous species in park was reported as high as 81% [24], or in parks in the South Korean city of Chonju, where exotic species constitute less

than 30% of the population [25-26]. Rapid adaptive capacities of the exotics make them better suited for environment and thus preferred. The presence of exotics in Vadodara gardens is not high, but requires intervention at this junction to promote plantation of indigenous species.

On comparing the habit of the all the 217 species recorded, it was found that 52% of the species represented trees, 28% shrubs and 12% herbs (Fig. 2). Climbers and grasses represented only 5% and 0.92% respectively. The trees largely belonged to evergreen and introduced species. Similar finding was reported in Bangalore gardens, where 88% of the trees were exotic in nature [10]. About 50% of the herbs belonged to introduced species and largely represented cactus species. Cactus is easy to grow and requires less maintenance, hence is preferred in the parks.

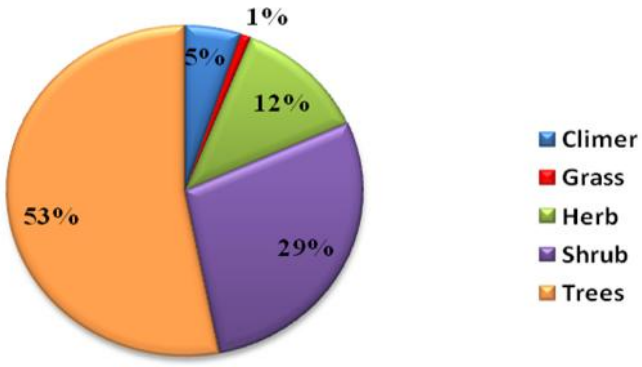


**Fig. 2.** Representation of different life forms in the gardens

The species distribution in different garden categories indicated presence of around 142 species in category 1, 105 species in category 2 and 112 species in category 3. This showed that smaller gardens (less than 5 ha) have larger diversity compared to larger garden (more than 10 ha). In case of larger gardens, there is plantation of similar species over large areas to improve the aesthetic value and in this regards a decline in diversity was reported. Similar findings were reported [27-28], where they showed that very small in area tend to be characterized by high levels of diversity and microhabitat heterogeneity, with large proportions of exotic species. These small areas then constitute critical biodiversity hotspots [15-19].

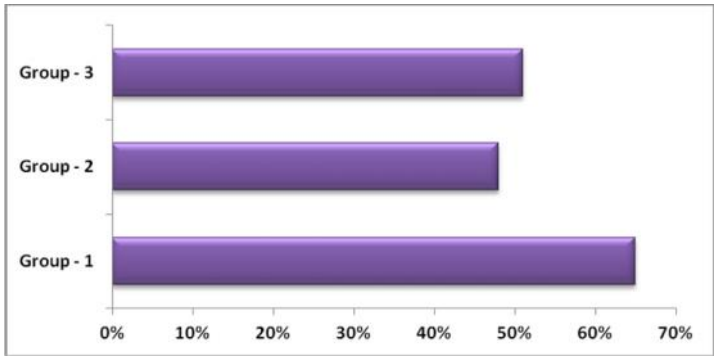


**Fig. 3.** Group wise distribution of species

Species distribution in each category differed and S*ansevieria trifasciata, Platycladus orientalis Jasminum sambac* was the most common species in category 1 gardens. All the species are ornamental and easy to maintain in smaller space. While in category 2 gardens, *Bougainvillea, Casuarina equisetifolia, Sansevieria trifasciata* were the most common species. *Bougainvillea* is used as hedges along the boundary with high aesthetics value and improve the look of the garden. *Sansevieria trifasciata* is the most common species found in all the gardens and native to tropical West Africa from Nigeria east to the Congo. The species grows well in warmer climates like Vadodara and requires low watering. In case of category 3 species with green canopy was reported like *Alstonia scholaris, Bauhinia purpurea, Catharanthus roseus, Delonix regia, Ficus religiosa* and *Tabernaemontana divaricata*.

## Conclusion

Thus, the parks and gardens have shown presence of multi taxa. It is concluded that diversity is more in the small gardens, whereas in the gardens above 10ha where plantation of few species is preferred. There is presence of exotics in the gardens, which could be replaced with indigenous species and the findings point towards possible study of faunal diversity to relate the vegetation characteristics of the gardens in Vadodara city.

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