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## Studies on Butterfly diversity, abundance and utilization of plant resources in urban localities of Banyan city- Vadodara, Gujarat, India

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### Abstract

Beginning of urbanization is one of the major reasons for habitat fragmentation with environmental degradation, a big threat for decline in species diversity in butterflies. Vadodara, a developing city in Western India fully indulged into establishment of cement & concrete jungles, which have fragmented natural green habitat up to the significant extent. Hence the present study is an attempt to study the species richness and to study availability of larval and nectar resources with respect to preferential colors in urban areas. During the extensive study; Nymphalidae and Pieridae families showed more number of the butterflies species, supported by diversity indices, within limited supply of the major nectar resources like *Lantana camara*, *Tridax procumbens* & *Ixora coccinea* with whitish yellow, yellowish orange and red color flowers, which should be cultivated most during urban designing to provide sustainable resources to restore biodiversity of this natural pollinators in developing cities like Vadodara.

**Keywords:** Butterflies, Flower Color Preference, Nectar resources, Urban Landscaping, Vadodara

### 1. Introduction

Advent of urbanization has led to the habitat fragmentation which is the major cause for environmental degradation as well as responsible for decline in species richness in butterflies & terrestrial biodiversity<sup>[15]</sup>. Little research has been carried on the impact of urbanization and focuses on enlightening human inhabitants of urbanized areas to improve the impacts on species conservation in all ecosystems<sup>[10]</sup>. The species diversity tends to decline with the habitat modification and habitat loss. Thus, urbanization has an immense impact on biodiversity<sup>[1]</sup>.

Pollinators such as butterflies, moths, bees form an integral part of our environment and play an important role in 35% of global crop production and sustain diverse wildlife groups<sup>[9]</sup>. Pollination is one such substantial activity observed in nature which ultimately bridges up the interaction between plants and butterflies and grades their interrelationship importance<sup>[2]</sup>. The Banyan City-Vadodara is a developing and lush green city in the state of Gujarat of Western India, located at the banks of river Vishwamitri having an average rainfall. But in the past few years, due to increasing urban population & advent of urbanization the city is fully indulged into establishment of more and more numbers of residential schemes, highways & fly-over bridges which have fragmented natural habitat up to the significant extent. Urbanization has side-lined the confined plant resources characterizing very limited urban landscapes and leading to the biotic homogenization<sup>[11]</sup>. With the restricted availability of plant resources, butterflies became peculiar in nectar consumption and became selective for flower colours as primary preference followed by scent<sup>[12]</sup>.

Thus, the primary objective of the present study was to observe the species richness and abundance of Rhopalocera in the urban areas of a developing city-Vadodara. The secondary objective was to study availability of nectar resources in the city with respect to preferential colors with an attempt to change the common mind-set for urban landscaping. So, ultimately the prime watchword of the present study was to draw out the main importance of selection of plant resources during urban designing hereby to provide sustainable resources for butterflies, which are playing a splendid role in pollination.

## 2. Materials and Methods

### 2.1 Study Area

Vadodara is known as Banyan city owing to the presence of large number of Banyan trees *Ficus benghalensis*. Vadodara is located at 22° 18' 00" N latitude and 73° 12' 01" E longitude in Gujarat state in western region of India situated at the banks of river Vishwamitri, the city covers an area of approximately 160sq kms.

The city receives an average rainfall of 800 mm. The approximate temperature ranges from 25 to 42°C. A total of 77 public gardens were developed in different zones of Vadodara as obtained from Vadodara Mahanagar Seva Sadan (VMSS) [18] and since last decade, the city exhibited a remarkable augmentation of urban population and establishments of high-tech residential schemes, express highways & fly-overs. Such heavy infrastructures hereby ruin the natural plant spread.

### 2.2 Data Collection

Study was carried out for a period of consecutive three years i.e. from the year 2012 to 2014. Prominent urban areas considered for the study, starting from the North direction in clockwise manner, were Sama, Fatehpura, Wadi, Makarpura, Tandalja, Alkapuri and Nizampura. Sweep net method and visual observations were utilized to document the butterflies. Pollard walk method was utilized to document the butterflies. The transect visits were made at 900-1200 and 1500-1800 hours according to Indian Standard Time format. Each transect was visited for a period of 2-3 hours and visibility was kept at 10 meters on the either side of transect. The geographical and meteorological details were recorded for the study.

### 2.3 Observations on Flower Color Preference by Butterflies

During the monthly visits carried out at selected sites, continuous observations were made on the number of butterflies visiting the preferred colored flower. The observations were made during the regular transect walk sampling and no separate time was allotted for the same.

The abundance of the butterfly species were made depending upon the sightings made during the survey into (i) Very common (>25 sightings during the entire survey), (ii) Common (10- 25 sightings) and (iii) Rare (1 - 5 sightings during the entire study)

From among large number of field guides and references, Evans (1932) made familiar to the Indian butterflies and other related aspects [3]. Along with it, the identification of the butterfly fauna was also carried out referring the standard references of Kehimkar (2008), Kunte (2000), Parasharya and Jani (2007) and Wynter-Blyth (1957) [5, 8, 13, 21].

### 2.4 Data Analysis

Alpha diversity indices were utilized to analyze butterfly diversity using statistical software PAST version 2.17c:

1. Shannon-Weiner Diversity Index: It states the number of species within site with the relative abundance of each species. It is defined as:

$$H' = -\sum p_i \ln p_i$$

Where,  $p_i$  = proportion of the  $i^{\text{th}}$  species in the total sample

2. Pielou's Evenness Index: It states the distribution of relative abundance of species in a site. The value of J ranges from 0 to 1.

$$J = H' / \ln S, \text{ Where, } S = \text{Number of species present in the site}$$

## 3. Results and Discussion

### 3.1 Butterfly species composition

During the entire course of study in the urban localities of Vadodara, a total of 43 species of butterflies were observed belonging to 29 genera and 5 families. Out of which, 6 species belong to family Papilionidae, 15 species belong to family Nymphalidae, 12 species belong to family Pieridae, 8 species belong to family Lycaenidae and 2 species from family Hesperidae were observed. Observations on the butterfly abundance were categorized into Very Common, Common and Rare. Out of the total 43 butterfly species observed, 11 butterfly species were very common, 23 butterfly species were common and 9 species being rare. The observed number of butterfly species and its abundance in respective urban areas of Vadodara are systematically listed in Table 1 along with Indian Wildlife Protection Act (IWPA) status. The presence and abundance of butterflies mark the importance of the plant resources available in these urban localities for their survival. Individual rarefaction plot is shown in Fig.1 depicting butterfly species observed in the urban areas of Vadodara.

Shannon-Weiner diversity value calculated was 3.46 and Pielou's Evenness Index value calculated was 0.741. The diversity index values indicate moderate level of species diversity and show certain gradient of variation in the species evenness.

Butterfly monitoring is carried out not only in urban locality but also in human dominated sites. Recently, butterfly assemblages were surveyed in cultivated agricultural landscapes in the vicinity of industrial park in Kechnec, Slovakia and recorded 45 butterfly species belonging to 5 families [6]. Moreover, the duo also focused on retaining wind protection margins for maintenance of butterfly species in such landscapes.

**Table 1:** Butterfly species in urban vicinity of Vadodara with its abundance and IWPA status (WPA 1972) (Where abundance is depicted as VC=Very Common, C=Common, R=Rare)

| Sr. No | Family       | Common Name          | Scientific Name                                   | Abundance | IWPA status (WPA 1972) |
|--------|--------------|----------------------|---|-----------|------------------------|
| 1      | Papilionidae | Lime butterfly       | <i>Papilio demoleus</i> (Linnaeus, 1758)          | VC        |                        |
| 2      |              | Common Mormon        | <i>Papilio polytes</i> (Linnaeus, 1758)           | C         |                        |
| 3      |              | Common Rose          | <i>Pachliopta aristolochiae</i> (Fabricius, 1775) | C         |                        |
| 4      |              | Crimson rose         | <i>Pachliopta hector</i> (Linnaeus, 1758)         | C         | Schedule-I             |
| 5      |              | Tailed Jay           | <i>Graphium agamemnon</i> (Linnaeus, 1758)        | VC        |                        |
| 6      |              | Common Jay           | <i>Graphium doson</i> (C& R. Felder, 1864)        | VC        |                        |
| 7      | Nymphalidae  | Common Evening Brown | <i>Melanitis leda</i> (Linnaeus, 1758)            | C         |                        |
| 8      |              | Tawny Coster         | <i>Acraea violae</i> Fabricius, 1775              | C         |                        |
| 9      |              | Common Castor        | <i>Ariadne merione</i> (Cramer)                   | C         |                        |
| 10     |              | Angled Castor        | <i>Ariadne ariadne</i> Linnaeus, 1763             | C         |                        |
| 11     |              | Yellow Pansy         | <i>Junonia hierta</i> (Fabricius, 1798)           | R         |                        |
| 12     |              | Blue Pansy           | <i>Junonia orithiya</i> (Linnaeus, 1758)          | R         |                        |

|    |                   |                     |  |  |                 |
|----|-------------------|---------------------|--|--|-----------------|
| 13 |                   | Lemon Pansy         | <i>Junonia lemonias</i> (Linnaeus, 1758)       | C  |                 |
| 14 |                   | Peacock Pansy       | <i>Junonia almana</i> (Linnaeus, 1758)         | R  |                 |
| 15 |                   | Grey Pansy          | <i>Junonia atlites</i> (Linnaeus, 1763)        | R  |                 |
| 16 |                   | Danaid Eggfly       | <i>Hypolimnas misippus</i> (Linnaeus, 1764)    | C  | Schedule I & II |
| 17 |                   | Great Eggfly        | <i>Hypolimnas bolina</i> (Linnaeus, 1758)      | VC                                       |                 |
| 18 |                   | Plain Tiger         | <i>Danaus chrysippus</i> Linnaeus, 1758        | VC                                       |                 |
| 19 |                   | Striped Tiger       | <i>Danaus genutia</i> Cramer, 1779             | R  |                 |
| 20 |                   | Common Indian Crow  | <i>Euploea core</i> (Cramer,1780)              | VC                                       | Schedule-IV     |
| 21 |                   | Black Rajah         | <i>Charaxes solon</i> (Fabricius,1793)         | C  |                 |
| 22 | Pieridae          | Common Emigrant     | <i>Catopsilia pomona</i> Fabricius, 1775       | VC                                       |                 |
| 23 |                   | Mottled Emigrant    | <i>Catopsilia pyranthe</i> Latreille,1758      | VC                                       |                 |
| 24 |                   | Small Grass Yellow  | <i>Eurema brigitta</i> Cramer, 1780            | VC                                       |                 |
| 25 |                   | Common Grass Yellow | <i>Eurema hecabe</i> Linnaeus, 1758            | VC                                       |                 |
| 26 |                   | Common Jezebel      | <i>Delias eucharis</i> Drury, 1773             | C  |                 |
| 27 |                   | Common Gull         | <i>Cepora nerissa</i> Fabricius, 1775          | C  | Schedule-II     |
| 28 |                   | Pioneer             | <i>Belenois aurota</i> Fabricius, 1793         | C  |                 |
| 29 |                   | White orange Tip    | <i>Ixias marianne</i> Cramer, 1779             | C  |                 |
| 30 |                   | Yellow orange Tip   | <i>Ixias pyrene</i> Linnaeus, 1764             | C  |                 |
| 31 |                   | Crimson Tip         | <i>Colotis danae</i> (Fabricius, 1775)         | C  |                 |
| 32 |                   | Small Salmon Arab   | <i>Colotis amata</i> Fabricius, 1775           | VC                                       |                 |
| 33 |                   | Common Albatross    | <i>Appias albino</i> Boisduval, 1836           | C  |                 |
| 34 |                   | Lycaenidae          | Common Pierrot                                 | <i>Castalius rosimon</i> Fabricius, 1775 | C               |
| 35 | Angled Pierrot    |                     | <i>Caleta caleta</i> Hewitson, 1876            | C  |                 |
| 36 | Rounded Pierrot   |                     | <i>Tarucus extricatus</i> Butler, 1886         | C  |                 |
| 37 | Zebra blue        |                     | <i>Leptotes plinius</i> Fabricius, 1793        | C  |                 |
| 38 | Plains Cupid      |                     | <i>Chilades pandava</i> Horsfield, 1829        | C  |                 |
| 39 | Lesser Grass Blue |                     | <i>Zizina otis</i> Fabricius, 1787             | C  |                 |
| 40 | Common Silverline |                     | <i>Spindasis vulcanus</i> Fabricius,1775       | R  |                 |
| 41 | Indian Sunbeam    |                     | <i>Curetis thetis</i> Drury,1773               | R  |                 |
| 42 | Hesperiidae       | Rice Swift          | <i>Borbo cinnara</i> (Wallace, 1866)           | R  |                 |
| 43 |                   | Brown Awl           | <i>Badamia exclamationis</i> (Fabricius, 1775) | R  |                 |

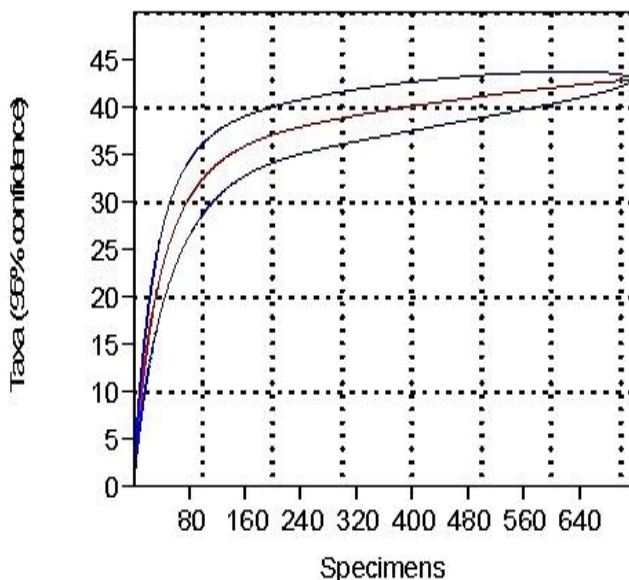


Fig 1: Individual rarefaction graph showing the individual species observed in the urban vicinity of Vadodara

### 3.2 Nectar and Host Plant Utilization by Butterflies

Abundance of butterflies was due to the presence of nectar resources. A detailed list of plant resources available in Vadodara along with its phenological details are shown in Table 2. A total of 19 different prominent plant species belonging to 11 families were observed. Of which, 4 plant

species belong to Apocynaceae, 3 species from Fabaceae, 2 plant species belonging to Moraceae, Rubiaceae and Rutaceae And 1 plant species each from Annonaceae, Asteraceae, Euphorbiaceae, Meliaceae, Nyctaginaceae and Verbanaceae. Amongst these, *Annona squamosa* serves as host plant for *Graphium agamemnon* and hereby being one of the very common butterflies found at these sites. *Polyalthia longifolia* is utilized by both *Graphium doson* and *Graphium agamemnon*. Such urban habitats also show presence of *Calotropis gigantea* which serves as host plant for *Danaus chrysippus*. *Murraya koenigii*, popularly known as Curry tree, is a host plant for Common Mormon (*Papilio polytes*). This curry tree serves an important ingredient in Indian delicacy and hence holds a significant existence in urban gardens. *Nerium oleander* serves as host plant for Common Indian Crow (*Euploea core*). *Ixora coccinea*, a red flowered shrub, is found in almost every residential gardens of the city. It's one of the most visible and common nectar resource for rhopalocerans like emigrants, yellows, papilionids, etc. present in the urban vicinity. Earlier study was carried out in Vadodara and revealed a total of 42 butterfly species belonging to 31 genera and 5 families from the major areas of the district [7]. Common Jay *Graphium doson* which was not observed in the earlier study was documented in the present study. Past study has also showed that the butterfly decline can be linked to decline in the overall flower and nectar abundance [20]

**Table 2:** List of plant resources utilized by butterflies with phenological details

| Sr. No | Family        | Botanical Name                                 | Local Name              | Plant Type                | Flower Color                       | Flowering Season    |
|--------|---------------|--|-------------------------|---------------------------|------------------------------------|---------------------|
| 1      | Annonaceae    | <i>Annona squamosa</i> L.                      | Sugar Apple             | Small Tree                | Greenish Yellow                    | March-April         |
| 2      | Apocynaceae   | <i>Alstonia scholaris</i> L. R. Br.            | Indian Devil Tree       | Medium Sized Tree         | White                              | October             |
| 3      | Apocynaceae   | <i>Nerium oleander</i> L.                      | Oleander                | Shrub                     | White, Pink, Red                   | March-May           |
| 4      | Apocynaceae   | <i>Vinca rosea</i> L.                          | Periwinkle              | Sub-Shrub                 | Violet                             | Throughout the year |
| 5      | Apocynaceae   | <i>Calotropis gigantea</i> L. R. Br.           | Milkweed                | Shrub                     | White- Pale Purple                 | Throughout the year |
| 6      | Asteraceae    | <i>Tridax procumbens</i> L.                    | Coat buttons            | Herb                      | White-Yellow                       | May-December        |
| 7      | Euphorbiaceae | <i>Jatropha integerrima</i> Jacq.              | Peregrina/ Fire cracker | Large Shrub               | Red, Pink                          | Throughout the year |
| 8      | Fabaceae      | <i>Cassia fistula</i> L.                       | Golden shower tree      | Medium sized tree         | Yellow                             | March- May          |
| 9      | Fabaceae      | <i>Peltophorum pterocarpum</i> (DC.) K. Heyne. | Yellow Flame Tree       | Tall tree                 | Yellow                             | March –May          |
| 10     | Fabaceae      | <i>Albizia saman</i> F. Muell.                 | Rain Tree               | Tall tree                 | Pink white                         | March-May           |
| 11     | Meliaceae     | <i>Azadirachta indica</i> A. Juss.             | Neem Tree               | Tall Tree                 | White                              | January-May         |
| 12     | Moraceae      | <i>Ficus benghalensis</i> L.                   | Banyan tree             | Tall tree                 | Yellow                             | March-May           |
| 13     | Moraceae      | <i>Ficus religiosa</i> L.                      | Peepal Tree             | Tall Tree                 | Red                                | February            |
| 14     | Nyctaginaceae | <i>Bougainvillea</i> Comm.                     | Paper Tree              | Ornamental Plant/ Climber | Orange- Pink Bracts (White flower) | Throughout the year |
| 15     | Rutaceae      | <i>Murraya koenigii</i> (L.) Sprengel          | Curry Tree              | Small Tree                | White                              | April-May           |
| 16     | Rutaceae      | <i>Citrus limon</i> (L.) Burm.f.               | Lemon                   | Small Tree                | White                              | March-May           |
| 17     | Rubiaceae     | <i>Hamelia patens</i> Jacq.                    | Firebush                | Shrub                     | Reddish-Orange                     | Throughout the year |
| 18     | Rubiaceae     | <i>Ixora coccinea</i> L.                       | Jungle Flame            | Shrub                     | Red, Pink                          | Throughout the year |
| 19     | Verbenaceae   | <i>Lantana camara</i> L.                       | Wild Sage               | Shrub                     | Red Yellow Pink Orange             | Throughout the year |

### 3.3 Flower color preference shown by butterflies

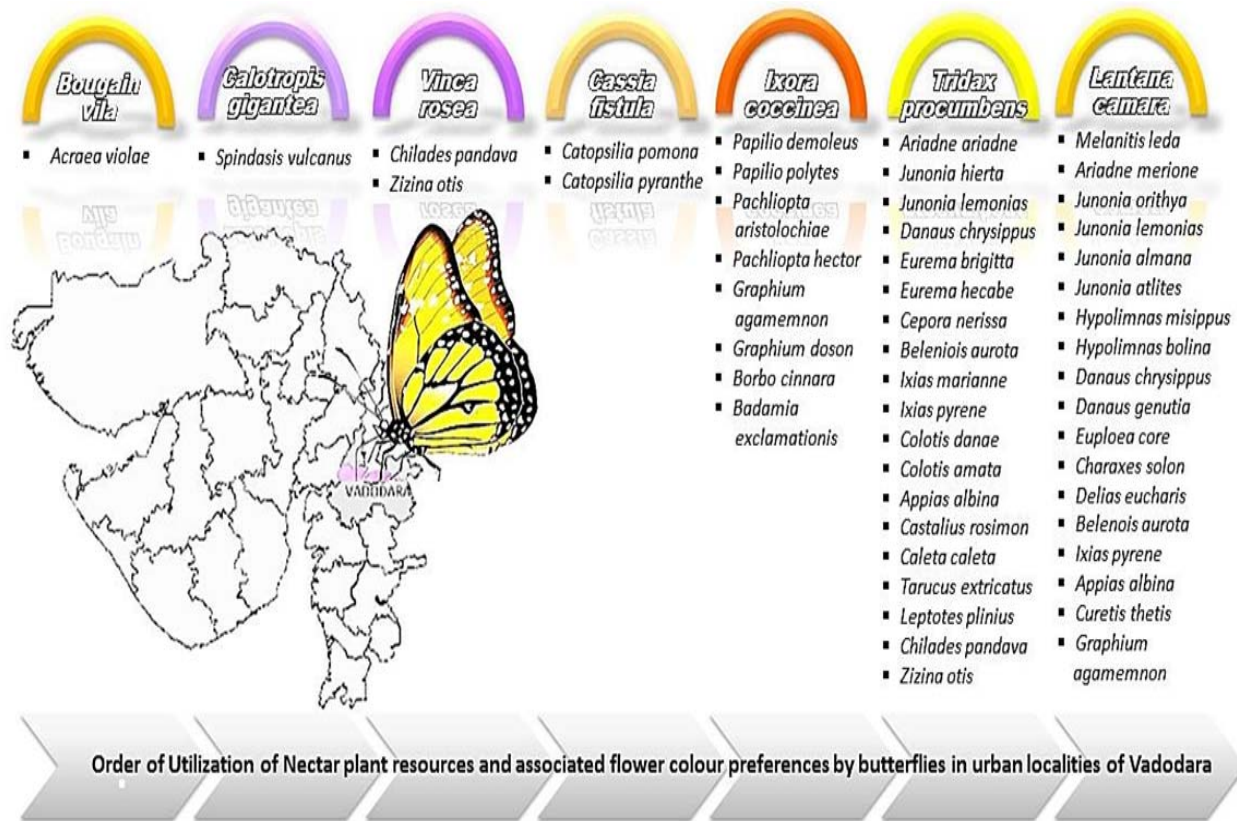
Floral color change benefits both plant and pollinator <sup>[19]</sup>. Present study has been carried out on flower color preference observed in butterflies. The most preferred nectar resources were *Ixora coccinea* and exotic invasive plant species *Lantana camara*. Members of family Papilionidae like *Papilio demoleus*, *Graphium agamemnon*, etc. were frequently observed on red flowers of *Ixora coccinea*. Fig. 2 represents the pictorial abstract of utilization of nectar resources & associated flower color preference by different butterfly species. Other nectar resources include the *Bougainvillea*, *Hamelia patens*, *Jatropha integerrima*, etc. attracts butterflies for nectar. Results show that rhopalocerans observed in the urban lands of Vadodara prefer more often white to yellow to red colored flower amongst the limited number of plant resources available. Flower color preference studies in Japan demonstrated that swallowtail butterflies and hawk moths primarily use color cues for flower visits and no significance preference for scent intensity <sup>[4]</sup>. Relevant study also revealed that butterfly showed preferences for flower color but when experimentally manipulated there was no constancy in foraging and hence may face the consequences of reduction in the effectiveness of butterfly visits <sup>[14]</sup>. Thus, the present study clearly depicts that such nectar resources with preferred color by these pollinators should be cultivated most during urban designing to restore such diversity.

### 4. Conclusion

The present study revealed a total of 43 butterfly species belonging to 5 families and 29 genera during the entire study period. This research work is a special effort to document & suggest effective ways to increase butterfly diversity in urban vicinity of Vadodara with specific preference to nectar rich plantation with specifically preferred colored flowers. In the past, research team from UK suggested that the management of the woodland sites should emphasize on nectar resources equally to that of host plants for butterfly conservation <sup>[17]</sup>. The degree of disturbance in urban environments is indicative of ecological responses of particular groups of plants and animals and hence helpful for developing strategies for conservation <sup>[16]</sup>. The present scenario indicates the urban lands as form of manmade modified habitat that restores the native diversity of butterflies with limited resources. Henceforth, this study was a special effort for knowledge amalgamation of urban landscaping and habitat restoration to raise the butterfly diversity. Further documentation of butterflies will be conducted to update the list.

### 5. Acknowledgments

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**Fig 2:** Nectar plant resources and associated flower color preferences by butterflies in urban localities of Vadodara

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