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Species Diversity, Color Quantification, And Light Adaptation of Plants with Red or Purple Abaxial Leaves in Urban Green Spaces of Shenzhen

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Abstract

To clarify the species composition, color attributes, and application characteristics of plants with red/purple abaxial leaves in urban green spaces, park green spaces, campus green spaces, and residential green spaces in Shenzhen were surveyed. The NCS-1950 color chart was used to quantify the abaxial leaf color of the recorded plants, and photosynthetically active radiation (PAR) and soil plant analysis development (SPAD) values were measured. A total of 41 species (including infraspecific taxa) with red/purple abaxial leaves were recorded, belonging to 12 families. Among them, Marantaceae had 11 species, Begoniaceae 14 species, Commelinaceae 4 species, Araceae 2 species, Acanthaceae 2 species and Asteraceae 2 species; the remaining species belonged to Euphorbiaceae, Zingiberaceae, Saxifragaceae, Lamiaceae, Musaceae, and Gesneriaceae. Abaxial NCS hues were mainly concentrated in the R–R50B interval, dominated by red and red-purple series, with an obvious gap in the blue-purple series. The largest numbers of plots were recorded for *Excoecaria cochinchinensis*, *Tradescantia spathacea*, and Marantaceae species. Begoniaceae was the most species-rich family but was concentrated under park canopies. *Excoecaria cochinchinensis* was the most sensitive to light environment changes and can serve as a candidate indicator species; Marantaceae and Begoniaceae had strong shade tolerance and are suitable for low-light environment configurations.

Keywords

Plants with red/purple abaxial leaves; Urban green space; NCS color chart; Light adaptation; Shenzhen.

1. INTRODUCTION

Colored-leaf plants are important materials in urban landscape design, but existing studies have mostly focused on adaxial leaf coloration types, such as spring flowering plants, autumn colored-leaf plants, and flower border color configuration[1-2]. The special phenomenon of red/purple abaxial leaves has rarely been reported. Red abaxial coloration is usually related to the anthocyanin layer in the abaxial epidermis and may have photoprotective, shade-adaptive, or defensive functions[3-4]. The abaxial anthocyanin layer can absorb blue-green light, thereby filtering and attenuating light and protecting internal leaf tissues from strong light damage[5]. Hughes and Lev-Yadun[6] reviewed that red/purple abaxial leaves have evolved independently in at least 100 genera of more than 50 angiosperm families, covering various life forms including understory herbs, lianas, shrubs, and aquatic plants; photoprotection is currently the most supported functional hypothesis. Klančnik et al. [7] showed that the red abaxial epidermis

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of Cyclamen purpurascens significantly reduces green and yellow light transmission, affecting leaf optical properties. Luo et al.,[8] using *Excoecaria cochinchinensis*, revealed that its permanently red abaxial leaves result from the co-localization of high levels of hydrolyzable tannins and anthocyanins, which inhibit peroxidase-mediated anthocyanin degradation and enhance color stability through copigmentation. These studies provide important clues for understanding red/purple abaxial leaves, but systematic surveys of such plants in urban green spaces are still lacking.

NCS color charts have the advantages of a wide color gamut and convenient classification and statistics in plant color quantification, and have been widely used in studies of spring flower color, autumn leaf color, and plant color in universities[9-11]. Shenzhen is located in the southern subtropics, with diverse urban green space types; the light environments of parks, campuses, and residential green spaces differ significantly, which may affect the distribution and coloration of plants with red/purple abaxial leaves. At present, research on colored-leaf plants in Shenzhen has accumulated to some extent. For example, Wang and Fu[12] investigated colored-leaf plants in the shrub-herb layers of park green spaces in Shenzhen and analyzed species and importance values under different environments, but no specialized report on red/purple abaxial leaf taxa has been found. This study took three types of urban green spaces in Shenzhen as objects, established a list of plants with red/purple abaxial leaves, quantified their abaxial NCS color attributes, analyzed family and genus composition, application scenarios, and number of plots, and focused on typical taxa such as Excoecaria cochinchinensis, Tradescantia spathacea, Marantaceae, and Begoniaceae, aiming to provide basic data for urban colored-leaf plant configuration and subsequent physiological mechanism research.

2. STUDY AREA AND METHODS

2.1. Study Area and Sampling Sites

The survey was conducted in Shenzhen, Guangdong Province, China, covering several districts including Futian, Nanshan, Bao'an, and Longgang. Park green spaces included Xiangmi Park, Lixiang Park, Xianhu Botanical Garden, Garden Expo Park, Bijiashan Park, and Honghu Park, etc.; campus green spaces included Shenzhen Polytechnic University, Shenzhen University, and Harbin Institute of Technology (Shenzhen), etc.; residential green spaces included Yicheng Center, Taoyuan Village, Taoyuanju, and Lingzhiyuan Xincun, etc. A total of 81 valid plots were obtained; one plant species was collected per plot, and five individuals were collected per species.

2.2. NCS Abaxial Leaf Color Quantification

An NCS-1950 portable color chart was used under diffused light to compare the middle part of the abaxial leaf (avoiding the main vein) and record the closest NCS code. The code format is ‘S sccc-AhhB’, parsed as blackness (s), chromaticness (ccc), and hue (AhhB). Hue series were divided according to the NCS color circle: red series (R, R10B–R20B), red-purple series (R30B–R60B), blue-purple series (R70B–R90B, B), orange-red series (Y50R–Y90R), yellow series (Y, Y10R–Y40R), yellow-green series (G10Y–G90Y), and green series (G).

2.3. PAR and SPAD Measurements

A Li-250A quantum sensor was used to measure PAR 10 cm above the canopy, with three replicates averaged; PAR in open areas was also recorded to calculate transmittance. A SPAD-502Plus was used to measure three mature leaves per plant, with three points per leaf averaged.

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2.4. Data Processing

Species names and green space types were standardized. The number of plots refers to the number of unique 'plot' codes in which the species occurred (five individuals collected per plot). One-way ANOVA and Pearson correlation analysis were used to compare differences among the three green space types and the relationships among PAR, SPAD, and abaxial leaf color attributes, with a significance level of $\alpha = 0.05$. Because PAR data were right-skewed, Table 2 describes them using median and interquartile range, while SPAD is described as mean ± standard deviation.

3. RESULTS AND ANALYSIS

3.1. List and Family/Genus Composition of Plants with Red/Purple Abaxial Leaves

As shown in Table 1, a total of 41 species with red/purple abaxial leaves were recorded, belonging to 12 families. Begoniaceae was the most species-rich family with 14 species, all in Begonia, including *Begonia coccinea*, *B. maculata*, *B. maculata* 'Wightii', *B.*'Daisy', *B. dietrichiana*, *B. fangii*, *B.* 'Mirage', *B.* 'Phantom', *B.* 'Golden Line', *B.* 'Ossota', *B. masoniana*, *B.* 'Thurstonii', *B. ulmifolia*, and *B.* 'Joe Hayden'. Marantaceae had 11 species, including *Goeppertia makoyana*, *Stromanthe sanguinea*, *Calathea veitchiana*, *Stromanthe sanguinea* 'Stripestar', *Ctenanthe setosa*, *Goeppertia rufibarba*, *Goeppertia roseopicta*, *Calathea majestica*, *Goeppertia warszewiczii*, *Phrynium rheedei*, and *Ctenanthe oppenheimiana*. Commelinaceae had 4 species: *Tradescantia spathacea*, *T. pallida*, *T. zebrina*, and *T. cerinthoides* 'Nanouk'. Acanthaceae, Araceae, and Asteraceae each had 2 species: *Strobilanthes auriculata* var. *dyeriana* and *Pseuderanthemum maculatum* (Acanthaceae); *Philodendron erubescens* and *Alocasia* 'Regal Shields' (Araceae); *Gynura bicolor* and *Emilia sonchifolia* (Asteraceae). The remaining six families each had one species: *Excoecaria cochinchinensis* (Euphorbiaceae), *Nautilocalyx lynchii* (Gesneriaceae), *Clerodendrum quadriloculare* (Lamiaceae), *Ensete glaucum* (Musaceae), *Heuchera* sp. (Saxifragaceae), and *Kaempferia rotunda* (Zingiberaceae).

3.2. Overall Characteristics of Abaxial NCS Color

It shows that abaxial NCS blackness ranged from S 20 to S 80, chromaticness from 05 to 60, and hues were concentrated in the R–R50B interval (Table 1 and Figure 1). The red series (R–R20B) had the largest number of species (24 species), mainly Begoniaceae and Marantaceae, with chromaticness mostly between 30 and 60 for Begoniaceae and between 05 and 60 for Marantaceae; the red-purple series (R30B–R60B) included *Pseuderanthemum maculatum*, *Alocasia* 'Regal Shields', *Gynura bicolor*, *Emilia sonchifolia*, *Tradescantia spathacea*, *T. pallida*, *T. zebrina*, *T. cerinthoides* 'Nanouk', *Clerodendrum quadriloculare, Goeppertia makoyana*, *Calathea majestica*, *Phrynium rheedei*, and *Ctenanthe oppenheimiana*, with generally high blackness (S 60–S 80) except for *T. cerinthoides* 'Nanouk' (S 30); the orange-red series (Y50R–Y90R) was only found in four species, namely *Philodendron erubescens*, *Begonia dietrichiana, Begonia* 'Joe Hayden', and *Excoecaria cochinchinensis*; no target species were recorded in the blue-purple series, indicating an obvious hue gap. In terms of chromaticness, the highest abaxial chromaticness (60) was found in *Begonia* 'Golden Line', *Begonia* 'Thurstonii', and *Stromanthe sanguinea* 'Stripestar', followed by *Excoecaria cochinchinensis* and *Tradescantia cerinthoides* 'Nanouk' (50). Marantaceae mostly ranged from 10 to 20, while Begoniaceae showed a wider range from 20 to 60. In terms of blackness, Marantaceae generally had high abaxial blackness (S 60–S 80), Begoniaceae was intermediate (S 35–S 70), and *Excoecaria cochinchinensis* had moderate blackness (S 45).

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Table 1. Species list, life forms, NCS color characteristics, application scenarios, and mean PAR and SPAD values of plants with red or purple abaxial leaves across three urban green space types in Shenzhen, China.

Family	Species	Life form	Abaxial NCS value	Color swatch	Hue series	Applied green space type	Application scenario	Number of plots	Mean PAR ($\mu mol \cdot m^{-2} \cdot s^{-1}$)	Mean SPAD
Euphorbiaceae	*Excoecaria cochinchinensis*	Shrub	S 4550-Y90R		Orange-red	Park, campus, residential	Semi-shade, full sun, full shade	14	102.7±119.3	48.7±7.8
Commelinaceae	*Tradescantia spathacea*	Herb	S 7020-R30B		Red-purple	Park, campus, residential	Semi-shade, full sun, full shade	10	290.0±310.5	46.4±12.1
Marantaceae	*Goeppertia makoyana*	Herb	S 7010-R30B		Red-purple	Park, residential	Semi-shade, full shade	4	25.6±24.4	42.4±14.2
Marantaceae	*Stromanthe sanguinea*	Herb	S 7020-R20B		Red	Park	Semi-shade, full shade	4	47.6±58.9	69.8±6.2
Acanthaceae	*Strobilanthes auriculata* var. *dyeriana*	Herb	S 8010-R10B		Red	Park	Semi-shade, full sun	3	76.1±68.7	43.6±5.9
Begoniaceae	*Begonia coccinea*	Herb	S 6030-R		Red	Park, residential	Semi-shade	3	101.5±54.2	37.7±5.1
Lamiaceae	*Clerodendrum quadriloculare*	Shrub/small tree	S 7010-R30B		Red-purple	Park	Semi-shade, full sun, full shade	3	355.7±262.4	60.4±13.2
Araceae	*Philodendron erubescens*	Herb/liana	S 6020-Y70R		Orange-red	Park	Semi-shade	2	25.7±17.6	69.9±8.5
Marantaceae	*Calathea veitchiana*	Herb	S 7020-R10B		Red	Park	Semi-shade	2	130.3±52.4	55.0±6.8
Marantaceae	*Stromanthe sanguinea* 'Stripestar'	Herb	S 2060-R10B		Red	Park, residential	Semi-shade	2	30.4±8.1	65.2±13.7
Marantaceae	Ctenanthe setosa	Herb	S 7010-R10B		Red	Residential	Semi-shade	2	70.2±68.3	58.2±9.6
Begoniaceae	*Begonia maculata*	Herb	S 5040-R		Red	Park	Semi-shade	2	52.1±24.9	37.9±6.8
Commelinaceae	*Tradescantia pallida*	Herb	S 6020-R40B		Red-purple	Campus, residential	Semi-shade	2	103.3±48.2	40.9±5.7
Begoniaceae	*Begonia maculata* 'Wightii'	Herb	S 5040-R		Red	Park	Semi-shade	1	19.6±8.4	43.9±2.1
Marantaceae	*Goeppertia rufibarba*	Herb	S 7020-R20B		Red	Park	Semi-shade	1	28.0±5.4	46.8±13.4
Marantaceae	*Goeppertia roseopicta*	Herb	S 8005-R		Red	Residential	Semi-shade	1	32.7±2.2	41.3±4.4
Begoniaceae	*Begonia* 'Daisy'	Herb	S 6030-R		Red	Park	full shade	1	27.3±2.4	49.5±4.3
Begoniaceae	*Begonia dietrichiana*	Herb	S 5040-Y90R		Orange-red	Park	Semi-shade	1	86.1±6.9	23.5±3.0
Araceae	*Alocasia* 'Regal Shields'	Herb	S 7005-R50B		Red-purple	Park	Semi-shade	1	116.5±11.7	56.5±2.2
Commelinaceae	*Tradescantia zebrina*	Herb	S 7020-R30B		Red-purple	Residential	Semi-shade	1	42.7±13.5	35.8±5.3
Saxifragaceae	*Heuchera* sp.	Herb	S 5030-R20B		Red	Park	Full sun、Semi-shade	1	191.9±32.0	23.8±2.7
Begoniaceae	*Begonia fangii*	Herb	S 5030-R		Red	Park	Semi-shade	1	104.6±32.6	38.5±6.8
Zingiberaceae	*Kaempferia rotunda*	Herb	S 6020-R20B		Red	Park	Semi-shade	1	333.3±129.1	38.5±4.5
Begoniaceae	*Begonia* 'Mirage'	Herb	S 5030-R		Red	Park	Semi-shade	1	25.2±2.9	19.6±2.5
Asteraceae	*Gynura bicolor*	Herb	S 7020-R30B		Red-purple	Campus	Semi-shade	1	56.3±7.0	48.1±3.6
Begoniaceae	*Begonia* 'Phantom'	Herb	S 6030-R		Red	Park	Semi-shade	1	60.6±34.7	35.3±4.4
Begoniaceae	*Begonia* 'Golden Line'	Herb	S 3560-R		Red	Park	Semi-shade	1	20.3±3.7	51.3±2.3
Marantaceae	*Calathea majestica*	Herb	S 8010-R30B		Red-purple	Park	Semi-shade	1	26.4±4.6	63.1±4.6
Acanthaceae	*Pseuderanthemum maculatum*	Herb	S 5020-R30B		Red-purple	Park	Semi-shade	1	40.6±12.8	38.4±4.9
Begoniaceae	*Begonia* 'Ossota'	Herb	S 5030-R		Red	Park	Semi-shade	1	99.5±53.3	35.9±9.9
Marantaceae	*Goeppertia warszewiczii*	Herb	S 6020-R20B		Red	Park	Semi-shade	1	113.5±58.1	55.1±5.9
Begoniaceae	*Begonia masoniana*	Herb	S 4050-R10B		Red	Park	Semi-shade	1	108.2±22.6	26.2±4.8
Begoniaceae	*Begonia* 'Thurstonii'	Herb	S 3560-R		Red	Park	Semi-shade、full shade	1	24.6±3.4	34.6±3.0
Musaceae	*Ensete glaucum*	Herb	S 7020-R10B		Red	Park	Semi-shade	1	78.9±40.2	33.3±4.4
Asteraceae	*Emilia sonchifolia*	Herb	S 6020-R50B		Red-purple	Campus	Semi-shade	1	726.3±392.5	37.5±5.9
Commelinaceae	*Tradescantia cerinthoides* 'Nanouk'	Herb	S 3050-R40B		Red-purple	Residential	Full sun	1	153.2±39.7	35.3±10.6
Begoniaceae	*Begonia ulmifolia*	Herb	S 5040-R		Red	Park	Semi-shade	1	116.6±7.7	42.1±1.6
Marantaceae	*Phrynium rheedei*	Herb	S 7010-R30B		Red-purple	Park	Semi-shade	1	51.5±11.5	53.7±1.9
Begoniaceae	*Begonia* 'Joe Hayden'	Herb	S 7020-Y90R		Orange-red	Park	Semi-shade	1	101.4±18.6	45.6±1.7
Marantaceae	*Ctenanthe oppenheimiana*	Herb	S 6020-R30B		Red-purple	Residential	Full shade	1	5.7±0.7	57.9±4.4
Gesneriaceae	*Nautilocalyx lynchii*	Herb	S 6020-R10B		Red	Park	Semi-shade	1	152.0±10.8	41.3±1.2

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Note: The number of plots refers to the number of unique 'plot' codes in which the species occurred (five individuals collected per plot). PAR and SPAD are the mean ± sample standard deviation of all individuals of the species.

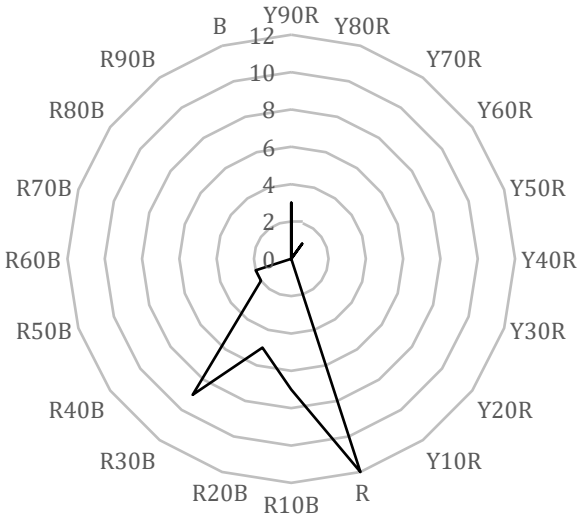


Figure 1. Polar coordinate plot of NCS hues of plant abaxial leaves

Using the NCS color circle as the base, the abaxial hues of 41 species were plotted on the circle. The results showed that hues were concentrated in the R, R10B, R20B, R30B, R40B, R50B, and Y90R intervals, with no distribution in the blue-purple region above R70B, indicating that plants with red/purple abaxial leaves in Shenzhen are mainly red to red-purple, with a lack of blue-purple resources.

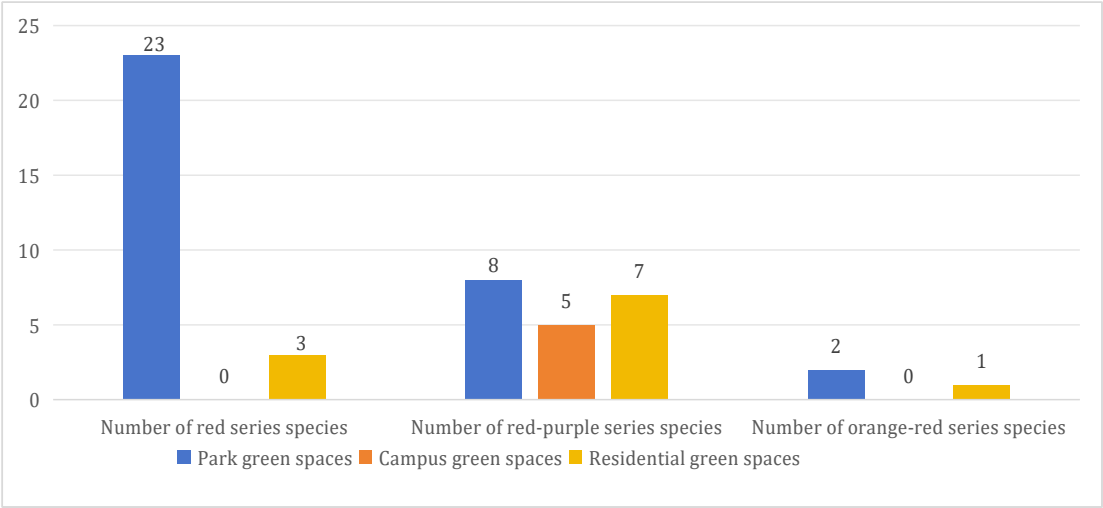


Figure 2. Species number and hue series distribution of plants with red/purple abaxial leaves in three green space types

Park green spaces had the largest number of species, comprising 23 red-series, 8 red-purple-series, and 2 orange-red-series species, mainly from Begoniaceae and Marantaceae. Residential green spaces were dominated by red-purple-series species (7 species), including *Tradescantia spathacea* and several Marantaceae species, together with 3 red-series and 1 orange-red-series

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species (*Excoecaria cochinchinensis*). Campus green spaces had the fewest species, with only 5 red-purple-series species and no red- or orange-red-series species, mainly *Tradescantia spathacea*, *Tradescantia pallida*, *Emilia sonchifolia*, and *Gynura bicolor*.

3.3. Differences in Light Environment and SPAD Among Green Space Types

PAR data in the three green space types were all obviously right-skewed, with standard deviations greater than means, reflecting high heterogeneity of light environments in urban green spaces. To reduce the influence of extreme values, median and interquartile range were used to describe PAR and transmittance. Campus green spaces had the highest median PAR (about 150 μmol $m^{-2}·s^{-1}$), followed by park green spaces (about 85 μmol $m^{-2}·s^{-1}$), and residential green spaces had the lowest (about 45 μmol $m^{-2}·s^{-1}$). In terms of SPAD, residential green spaces had the highest value (50.2 ± 13.1), followed by park green spaces (48.6 ± 15.4), and campus green spaces had the lowest value (43.5 ± 11.9), indicating that leaf relative chlorophyll content decreased under high-light environments.

Table 2. Comparison of light environment and leaf traits among three green space types.

Green space type	PAR median(μmol·$m^{-2}·s^{-1}$)	PAR interquartile range	Transmittance median	Transmittance interquartile range	SPAD mean ± SD
Park green space	85	40–170	0.30	0.15–0.50	48.6±15.4
Campus green space	150	60–400	0.50	0.30–0.75	43.5±11.9
Residential green space	45	25–110	0.35	0.20–0.55	50.2±13.1

Note: PAR was right-skewed and is described by median and interquartile range; SPAD was approximately normal and is described as mean ± standard deviation. Transmittance = plot PAR / simultaneous open-area PAR.

3.4. Focused Analysis of Typical Taxa

Excoecaria cochinchinensis was the most widely distributed species, occurring in 14 plots across all three green space types (Table 1). Its abaxial NCS code was S 4550-Y90R, belonging to the orange-red series, with moderate blackness (S 45) and relatively high chromaticness (50). Its mean SPAD was 48.7 ± 7.8 (Table 1). Luo et al. (2019) found that the permanently red abaxial leaves of *E. cochinchinensis* are related to high levels of hydrolyzable tannins in the abaxial leaf inhibiting peroxidase-mediated anthocyanin degradation, which explains its stable abaxial color and relatively high chromaticness.

Tradescantia spathacea was distributed in all three green space types (10 plots), with an abaxial NCS code of S 7020-R30B (red-purple series). Its mean PAR fluctuated greatly (290.0 ± 310.5 μmol $m^{-2}·s^{-1}$), covering full sun, semi-shade, and full shade, indicating a wide range of light adaptation. Its mean SPAD was 46.4 ± 12.1 (Table 1), showing certain plasticity.

Marantaceae had 11 species, the second most species-rich group among plants with red/purple abaxial leaves. Abaxial NCS values ranged from S 2060-R10B to S 8010-R30B, mainly in the red and red-purple series, with generally high blackness (S 60–S 80) and low to moderate chromaticness (05–30), except for *Stromanthe sanguinea* 'Stripestar' (chromaticness 60). This functional group was mainly used in park understory and semi-shaded residential environments; mean PAR was generally low (mostly <120 μmol m^{-2} s^{-1}), indicating the

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strongest shade tolerance, and mean SPAD was generally high (mostly above 50). Abaxial color showed no obvious response to PAR changes. Klančnik et al. (2016) showed that the red abaxial epidermis of *Cyclamen* significantly reduces green and yellow light transmission and reduces the risk of photoinhibition in mesophyll tissues, consistent with the function of the dark abaxial layer of Marantaceae in reducing transmission and protecting mesophyll.

Begoniaceae had 14 species, the most species-rich family, but its application scenarios were highly concentrated in park understory environments such as Xianhu Botanical Garden; only *Begonia coccinea* was found in residential green spaces. Abaxial NCS was mainly R, with a few species showing Y90R orange-red (e.g., *Begonia dietrichiana* and *Begonia* 'Joe Hayden'); mean SPAD ranged from 19.6 to 51.3, and chromaticness was generally moderate (30–40).



Figure 3. Photographs of typical leaves, plants, and application scenarios of plants with red/purple abaxial leaves.

3.5. Indicator Species Screening and Configuration Recommendations

Based on species distribution breadth, PAR–SPAD correlation, and abaxial color response amplitude, *Excoecaria cochinchinensis* can serve as a candidate indicator species for light environments in Shenzhen urban green spaces, suitable for monitoring along a semi-shade to full-sun gradient. *Tradescantia spathacea* is a moderately sensitive species. Marantaceae has the strongest shade tolerance and is suitable for low-light environments such as understory and building shadows. Begoniaceae is species-rich but has a narrow application range; it is recommended to appropriately expand its application in park understory and semi-shaded residential environments.

4. DISCUSSION

The abaxial anthocyanin layer of plants with red/purple abaxial leaves has light-filtering and light-attenuating functions, protecting internal leaf tissues from strong light by absorbing blue-green light[3, 5]. Recent studies have shown that abaxial anthocyanins, like adaxial anthocyanins, have photoprotective functions, especially important for shade-adapted plants during brief exposure to strong light [6]. In this survey, the high sensitivity of *E. cochinchinensis* to light environment was consistent with its relatively high abaxial chromaticness and large anthocyanin response amplitude. Marantaceae and Begoniaceae had low abaxial chromaticness but high blackness, possibly related to their long-term adaptation to

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low-light understory environments; the dark abaxial layer may help reflect green light and improve light capture efficiency under weak light. Cooney et al.[13] pointed out that the photoprotective effect of leaf anthocyanins is profoundly affected by the quality, intensity, and duration of light stress, and that anthocyanin light attenuation provides a functional advantage only when heat dissipation capacity is insufficient to quench excess light energy. This conclusion can explain the phenomenon in this study that *E. cochinchinensis* had relatively high abaxial chromaticness under full sun, while understory Marantaceae species had relatively low abaxial chromaticness.

Research on colored-leaf plants in Shenzhen has accumulated to some extent [12, 14], but no systematic report specifically on red/purple abaxial leaf taxa has been published. This survey fills this gap and uses the NCS color chart to quantify abaxial color, which is more comparable than traditional qualitative descriptions [9-10]. From the perspective of landscape application, *E. cochinchinensis* and *T. spathacea* have strong adaptability and occur in many plots, and can be used as backbone plants with red/purple abaxial leaves in Shenzhen urban green spaces; Marantaceae and Begoniaceae have high ornamental value but narrow application scenarios, and their configuration in understory and semi-shaded habitats can be strengthened in the future. It should be noted that NCS visual comparison is somewhat subjective, the sample size is unbalanced among species, and the survey was concentrated from May to July. Future studies can combine anthocyanin content, hydrolyzable tannins, peroxidase activity, and leaf optical measurements to further reveal the physiological and ecological mechanisms of abaxial coloration.

5. CONCLUSIONS

We can conclude that a total of 41 species of plants with red/purple abaxial leaves were recorded in three types of urban green spaces in Shenzhen, belonging to 12 families, among which Begoniaceae (14 species) and Marantaceae (11 species) were the two main groups. Abaxial NCS hues were concentrated in the R–R50B interval, with red and red-purple series dominant and blue-purple series absent; *E. cochinchinensis* had relatively high chromaticness, and Marantaceae had the highest blackness. Campus green spaces had the highest PAR and lowest SPAD, residential green spaces had the lowest PAR and highest SPAD, and park green spaces were intermediate. *E. cochinchinensis* was the most sensitive to light environment and can serve as a candidate indicator species; Marantaceae and Begoniaceae had the strongest shade tolerance and are suitable for low-light configurations.

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