Species and Distribution of Understory Plants in Parks

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Abstract. In order to understand the application status of undergrowth ground cover plants in Tianjin parks, the planting area and distribution of understory ground cover plants in aquatic parks, nancui Ping parks and Changhong parks in Tianjin were investigated by the methods of whole garden investigation and sample plot investigation. The results showed that there were 9 species of understory plants in the three parks: Hosta plantaginea (Lam.), Duchesnea indica (Andr.), Sabina rocumbens (endl.), Agave sisalana perR. Ex Engelm., iris lactea, Hemerocallis fulva (L.) L., Buxus megistophylla, Sedum aizoon L. and Rubia cordifolia L., belonging to 9 families 9 Genus. Among them, Hosta plantaginea (Lam.), Duchesnea indica (Andr.) and Sabina rocumbens (endl.) grew well, while iris lactea, Sedum aizoon L. and Rubia cordifolia L. grew poorly. The planting area of Duchesnea indica (Andr.) is the largest, Hemerocallis fulva (L.) L. is the smallest; the ratio of planting area to total park area is the highest, followed by Sabina rocumbens (endl.). The results showed that there were horsta plantaginea (Lam.), Duchesnea indica (Andr.), Sabina rocumbens (endl.), iris lactea, Hemerocallis fulva (L.) L., Buxus megistophylla, and Rubia cordifolia L., Agave sisalana perR. Ex Engelm. And Sedum aizoon L.Duchesnea indica (Andr.) had the highest distribution density, and Hosta plantaginea (Lam.) had the highest frequency. In a word, Horsta plantaginea (Lam.) was the most planted species, followed by Duchesnea indica (Andr.) and Sabina rocumbens (endl.), and the planting area of other species was the smallest.

Keywords: Undergrowth Plants, Park, Distribution

In recent years, because of its strong coverage, easy reproduction, extensive management, strong adaptability, and rich community level and visual effect, rural land cover plants have been paid more and more attention in urban and park landscaping [1]. Ground cover plants are indispensable in the application of understory green space, which avoids soil exposure and is also an important part of multi-layer plant landscape. Generally, the plants planted under the forest are shade tolerant or semi shade tolerant plants. They often have shade tolerance, semi shade tolerance, high temperature and humidity, and avoid direct sunlight and drought [2]. Especially in northern cities, due to climatic reasons, the species of plants that can be applied are greatly limited, which restricts the application and promotion of understory plants in the north.
At present, most of the researches on the shade tolerance of trees and shrubs in northern cities of China [3-6], and a few scholars have evaluated and studied the shade tolerance of land cover plants in northern China [7]. However, there are few studies on the ground cover plants which are being applied and can be applied or popularized in the future in the northern cities or parks. In addition, the species of ground cover plants suitable for planting under the forest in northern cities are less studied, at least the understory plants planted in the park have single color and poor ornamental value.

In this study, through the investigation of the undergrowth ground cover plants in Tianjin parks, the application situation of the understory plants was analyzed, so as to provide the basis for the allocation and promotion of understory plants in the future.

1. Materials and Methods

The selection of survey sites: Tianjin Water Park, Nancuiping Park and Changhong park were selected as the sample plots, and the three plots were all located in Nankai District of Tianjin. Among them, the water park is the largest comprehensive park in Tianjin [8], with an area of 125 hm², a water surface area of 75 hm², a land area of 50 hm², a greening area of 350000 m², and nearly 200 species of garden flowers and trees; the nancuiping Park covers an area of 335000 m², of which the greening area is about 319200 m², the mountain area is 121000 m², and the water area around the mountain is about 85000 m². More than 120000 trees and shrubs are planted on the mountain, 210000 trees are planted at the foot of the mountain, and hundreds of deciduous and evergreen plants such as Pinus tabulaeformis, juniper, Prunus davidiana, pseudoacacia pseudoacacia and Prunus persica [9]; Changhong Park covers an area of 33 hm², water surface of 12.5 hm², and the green area of the whole park accounts for 97.5%. There are more than 3000 evergreen trees and 12000 shrubs in the park more than 10000 bamboos, aquatic plants, perennial flowers and 41500 m² lawn [10].

The whole garden investigation method: the species of all undergrowth plants were investigated in the whole garden, carpet screening was conducted in the whole garden, the morphological characteristics of various plants were recorded, the plant species were determined through the key table, the distribution area and area of plants were recorded, and the percentage of each plant in the green space area of the park was calculated. According to plant height, coarseness, leaf color and occurrence of diseases and insect pests, the growth trend of plants was analyzed.

Sample plot investigation method: for all undergrowth greenbelts, the area of 10 m × 10 m was selected as the sample plot in the place where the plants grew evenly. The plant density (number of plants per unit area) and frequency (the percentage of the number of quadrats of a species in the total number of quadrats) were investigated.

2. Results and Analysis

2.1. Species and Growth of Understory Plants in Three Parks of Tianjin

The results of Table 1 show that there are 9 species of understory plants in Tianjin Water Park, Changhong Park, and Nancuiping Park, namely, Hosta plantaginea (Lam.), Agave sisalana perR. Ex Engelm., Duchesnea indica (Andr.), iris, Sabina, Hemerocallis fulva (L.), Buxus megaphylla, Sedum aizoon L., Rubia cordifolia50. It belongs to 9 families and 9 genera. They belong to Liliaceae, Agave family, Rosaceae, Iridaceae, Cupressaceae, Hemerocallis fulva (L.) family, Celastraceae, Rubia cordifolia family, Crassulaceae; Hosta plantaginea (Lam.), Agave, Duchesnea indica (Andr.), iris, Sabina, Hemerocallis fulva (L.) family, Euonymus, Rubia cordifolia family, Sedum.

Hosta plantaginea (Lam.) is a perennial herbaceous plant belonging to the genus Hosta plantaginea (Lam.) of Liliaceae family. It likes shady and humid environment, is cold resistant and avoids direct sunlight; it grows luxuriantly in well drained, fertile and moist sandy soil, with thick rhizome and multi fibrous roots [11]. Growing vigorously in various parks, it is the best species of all understory plants.
Agave sisalana per R. Ex Engelm. is a perennial plant of Agave sisalana per R. Ex Engelm. However, like the sunny place, low cold resistance, easy to occur physiological leaf spot disease [12]. In the South Cuiping Park and water park, the growth is more vigorous.

Duchesnea indica (Andr.) belongs to Duchesnea indica (Andr.) of Rosaceae. It is perennial herbaceous. It likes warm and humid environment, has few diseases and insect pests, extensive management and strong adaptability. It is more resistant to shade, drought, cold, water and humidity, barren, and likes to live in a semi shade and half positive or partial shade living environment, and its growth is poor under strong shade [13]. In each park, the growth is more vigorous.

Iris lactea belongs to iris family. It has strong cold resistance and perennial root herbs. It likes to grow in well drained and moderately humid soil, and the weak alkaline soil containing calcareous is the most suitable [14]. In the water park, the growth is weak.

Sabina rocumbens (endl.) is an evergreen creeping shrub of Cupressaceae. It likes light and has strong resistance to various soil adversities. It can grow normally in slightly acidic, neutral and slightly alkaline soil, and it is more resistant to salt alkali, wind, frost, cold and drought. It can also grow in stiff soil and coastal areas [15]. In the South Cuiping Park, it grows vigorously.

Hemerocallis fulva (L.) L. belongs to Hemerocallis fulva (L.) L. family. It is perennial perennial herb, light loving, cold resistant, drought resistant, humid and semi overcast. It has strong adaptability to soil, but it is better to have deep soil layer, rich humus, good drainage, fertile sandy loam, less diseases and pests, and can grow well in neutral and alkaline soil [16]. In the water park, the growth is weak.

Table 1. Species of understory plants in water park, Changhong Park and nancuiping Park in Tianjin

| No. | Type Branch, Family Genus | Type |
|-----|---------------------------|------|
| 1   | Hosta plantaginea (Lam.) Aschers Liliaceae Hosta | Perennial perennial herb flowers (Hardy) Flower viewing, leaf viewing |
| 2   | Agave sisalana Perr. ex Engelm. Agaveaceae Agave | Perennials (less hardy, Salt-tolerant) leaf viewing |
| 3   | Duchesnea indica (Andr.) Focke Rosaceae Duchesnea indica | Perennial herbs (hardy) Flower viewing, fruit viewing |
| 4   | Iris lactea Iris | Perennial herb perennial plant (Cold and salt resistant) leaf viewing |
| 5   | Sabina rocumbens(Endl.) Iwata et Kusaka Parker Juniper | Evergreen creeping shrub (Hardy) leaf viewing |
| 6   | Hemerocallis fulva(L.)L. Hemerocallis | Perennial herb (Hardy) Leaf viewing, flower viewing shrub |
| 7   | Buxus megistophylla Levl. Euonymus Buxus | Perennial grass climbing vine (Hardy) leaf viewing |
| 8   | Sedum aizoon L. Crassulaceae Crassula | Perennial succulent herbs (hardy) leaf viewing |
| 9   | Rubia cordifolia L. Rubiaceae Rubia | Perennial grass climbing vine (Hardy) leaf viewing |
Buxus megistophylla is a shrub or small tree belonging to Euonymus family. It is a temperate and subtropical tree species. It is light loving and shade tolerant. It likes warm and humid climate, and it is also cold resistant. It requires fertile and loose soil, extremely resistant to pruning and shaping [17]. In the water park, the growth is more vigorous.

Sedum aizoon L. is a perennial succulent herb of Sedum family, with short plant clusters and fleshy leaves. It has strong adaptability to the environment, high temperature and drought resistance, fast reproduction, easy cultivation and management, and can grow normally under the roof and shade (medium canopy) [18]. In the water park, the growth is weak.

Rubia cordifolia L. belongs to Rubia cordifolia L. of Rubia cordifolia L. family. It is perennial grass climbing vines. It likes cool and humid environment, cold resistant and afraid of ponding. For the soil, it is better to cultivate loose and fertile sandy loam rich in organic matter, and it is not suitable to plant in high dry terrain, barren soil and low-lying areas prone to ponding [19]. In the water park and Changhong Park, the growth is weak.

2.2. Application Analysis of Understory Plants in Three Parks of Tianjin

Table 2 shows that there are 9 species of understory plants in the water park: Hosta plantaginea (Lam.), Duchesnea indica (Andr.), Agave sisalana perR. Ex Engelm., Hemerocallis fulva (L.) L., Buxus megistophylla, iris lactea, Sedum aizoon L., Rubia cordifolia L., and Lonicera japonica. The order of planting area was as follows: plantain L. > plantain L. The area ratio of Hosta plantaginea (Lam.) was the largest (0.13%), followed by Duchesnea indica (Andr.) and iris lactea. Compared with other parks, the growth of understory plants in water park is better.

There are only Duchesnea indica (Andr.), Sabina rocumbens (endl.) and agave sisalana perR. Ex Engelm. The results showed that: Sabina rocumbens (endl.) > Duchesnea indica (Andr.) > agave sisalana perR. Ex Engelm. The area ratio was 0.58%, 0.14% and 0.004%. Sabina rocumbens (endl.).

There are 4 species of understory plants in Changhong Park: Hosta plantaginea (Lam.), Duchesnea indica (Andr.), Sedum aizoon L., Rubia cordifolia L. Among them, Duchesnea indica (Andr.) has the largest planting area and area ratio, while the others are small and scattered. There is a large area of lawn in the park, and there are less undergrowth plants.

Table 2. Planting area of different understory plants in three parks

| Plant name                          | Water Park (total green area of 350000 m²) | Nancuiping Park (total green area of 319200 m²) | Changhong Park (total green area of 330000 m²) |
|-------------------------------------|------------------------------------------|-----------------------------------------------|-----------------------------------------------|
|                                     | Planting area / m² | Area ratio /% | Planting area / m² | Area ratio /% | Planting area / m² | Area ratio /% |
| Hosta plantaginea (Lam.)            | 465.72          | 0.13         | 0                 | 0             | 15.86             | 0.005        |
| Duchesnea indica (Andr.)            | 45.57           | 0.013        | 455.71            | 0.14          | 387.28            | 0.1          |
| Sabina rocumbens (Endl.)            | 0               | 0            | 1835.90           | 0.58          | 0                 | 0            |
| Agave sisalana Perr. ex Engelm.     | 1.07            | 0.000 3      | 11.23             | 0.004         | 0                 | 0            |
| Hemerocallis fulva (L.)             | 5.4             | 0.001 5      | 0                 | 0             | 0                 | 0            |
| Buxus megistophylla                 | 15.51           | 0.004 4      | 0                 | 0             | 0                 | 0            |
| Iris lactea                         | 38.6            | 0.01         | 0                 | 0             | 0                 | 0            |
| Sedum aizoon L.                     | 15.75           | 0.004 5      | 0                 | 0             | 6.35              | 0.001 9      |
| Rubia cordifolia L.                 | 10.20           | 0.002 9      | 0                 | 0             | 1.12              | 0.000 3      |
Note: area ratio = (planting area / total green area) \times 100\%

2.3. Distribution of Understory Plants in Three Parks of Tianjin

Table 3 shows the distribution of understory plants in each park. There are 20 plots with understory plants in the water park, among which Hosta plantaginea (Lam.), Duchesnea indica (Andr.), Hemerocallis fulva (L.) L., Buxus megistophylla, iris lactea and Sedum aizoon L. are distributed in patches, Agave sisalana pers. ex Engelm. And Rubia cordifolia L. are scattered; 8 plots with understory plants in nancuiping park are Duchesnea indica (Andr.) and Sabina rocumbens (endl.), Agave sisalana pers. ex Engelm. Are sporadic; there are 5 plots with understory plants in Changhong Park, of which Hosta plantaginea (Lam.) and Duchesnea indica (Andr.) are distributed in patches, Sedum aizoon L. and Rubia cordifolia L. are sporadic.

The distribution of the same plants in different parks is as follows:

- Hosta plantaginea (Lam.), Sedum aizoon L., Rubia cordifolia L. distribution: Water Park > Changhong park.
- Duchesnea indica (Andr.) distribution: Water Park > Nancuiping Park > Changhong Park.
- Agave sisalana perR. Ex Engelm.

The planting density of Hemerocallis fulva (L.) L. was 0.3 plant \cdot m^{-2}, Buxus megistophylla was 0.1 plant \cdot m^{-2}, iris lactea was 0.1 plant \cdot m^{-2}. The density of Sabina rocumbens (endl.) in Nancuiping park is 3 plants \cdot m^{-2}.

Table 3. Distribution of understory plants in three parks

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | - | Piece by piece 1 |
| Duchesnea indica (Andr.) | Piece by piece 3 | Piece by piece 2 | Piece by piece 1 |
| Sabina rocumbens (Endl.) | - | Piece by piece 4 | - |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | Spora dic 2 | - |
| Hemerocallis fulva (L.) | Piece by piece 1 | - | - |
| Buxus megistophylla | Piece by piece 1 | - | - |
| Iris lactea | Piece by piece 2 | - | - |
| Sedum aizoon L. | Piece by piece 1 | - | Spora 2 |

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | 12 | 28% | Piece by piece 1 |
| Duchesnea indica (Andr.) | Piece by piece 3 | 101 | 9% | Piece by piece 2 |
| Sabina rocumbens (Endl.) | - | - | - | Piece by piece 4 |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | 0.4 | 3% | Spora dic 2 |
| Hemerocallis fulva (L.) | Piece by piece 1 | 0.3 | 3% | - |
| Buxus megistophylla | Piece by piece 1 | 0.1 | 3% | - |
| Iris lactea | Piece by piece 2 | 0.1 | 6% | - |
| Sedum aizoon L. | Piece by piece 1 | 80 | 3% | Spora 2 |

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | - | - |
| Duchesnea indica (Andr.) | Piece by piece 3 | - | - |
| Sabina rocumbens (Endl.) | - | - | - |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | - | - |
| Hemerocallis fulva (L.) | Piece by piece 1 | - | - |
| Buxus megistophylla | Piece by piece 1 | - | - |
| Iris lactea | Piece by piece 2 | - | - |
| Sedum aizoon L. | Piece by piece 1 | - | Spora 2 |

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | - | - |
| Duchesnea indica (Andr.) | Piece by piece 3 | - | - |
| Sabina rocumbens (Endl.) | - | - | - |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | - | - |
| Hemerocallis fulva (L.) | Piece by piece 1 | - | - |
| Buxus megistophylla | Piece by piece 1 | - | - |
| Iris lactea | Piece by piece 2 | - | - |
| Sedum aizoon L. | Piece by piece 1 | - | Spora 2 |

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | - | - |
| Duchesnea indica (Andr.) | Piece by piece 3 | - | - |
| Sabina rocumbens (Endl.) | - | - | - |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | - | - |
| Hemerocallis fulva (L.) | Piece by piece 1 | - | - |
| Buxus megistophylla | Piece by piece 1 | - | - |
| Iris lactea | Piece by piece 2 | - | - |
| Sedum aizoon L. | Piece by piece 1 | - | Spora 2 |

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | - | - |
| Duchesnea indica (Andr.) | Piece by piece 3 | - | - |
| Sabina rocumbens (Endl.) | - | - | - |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | - | - |
| Hemerocallis fulva (L.) | Piece by piece 1 | - | - |
| Buxus megistophylla | Piece by piece 1 | - | - |
| Iris lactea | Piece by piece 2 | - | - |
| Sedum aizoon L. | Piece by piece 1 | - | Spora 2 |

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | - | - |
| Duchesnea indica (Andr.) | Piece by piece 3 | - | - |
| Sabina rocumbens (Endl.) | - | - | - |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | - | - |
| Hemerocallis fulva (L.) | Piece by piece 1 | - | - |
| Buxus megistophylla | Piece by piece 1 | - | - |
| Iris lactea | Piece by piece 2 | - | - |
| Sedum aizoon L. | Piece by piece 1 | - | Spora 2 |

| Plant name | Aquatic Park | Nancuiping Park | Changhong Park |
|------------|-------------|----------------|---------------|
| Hosta plantaginea (Lam.) | Piece by piece 9 | - | - |
| Duchesnea indica (Andr.) | Piece by piece 3 | - | - |
| Sabina rocumbens (Endl.) | - | - | - |
| Agave sisalana pers. ex Engelm. | Spora dic 1 | - | - |
| Hemerocallis fulva (L.) | Piece by piece 1 | - | - |
| Buxus megistophylla | Piece by piece 1 | - | - |
| Iris lactea | Piece by piece 2 | - | - |
| Sedum aizoon L. | Piece by piece 1 | - | Spora 2 |
The order of the frequency of each species in the water park was: Hosta plantaginea (Lam.) > Duchesnea indica (Andr.) > iris lactea > agave sisalana perR. Ex Engelm. = Hemerocallis fulva (L.) L. = Buxus megistophylla = Sedum aizoon L. = Rubia cordifolia L., 28%, 9%, 6% and 3%, respectively.

The order of frequency of each species in nancui Ping Park was Sabina rocumbens (endl.) > agave sisalana perR. Ex Engelm. > Duchesnea indica (Andr.), which were 13%, 6% and 3%, respectively. The order of frequency of each species in Changhong Park was: Sedum aizoon L. > Rubia cordifolia L. = Duchesnea indica (Andr.) = Hosta plantaginea (Lam.), 6% and 3% respectively. Generally speaking, the distribution of Hosta plantaginea (Lam.) and Duchesnea indica (Andr.) in each park is relatively extensive and uniform.

3. Conclusion
There are 9 kinds of plants planted under the forest in three parks in Tianjin, including Hosta plantaginea (Lam.), Agave sisalana perR. Ex Engelm., Duchesnea indica (Andr.), iris lactea (Magnolia), Sabina rocumbens (endl.), Hemerocallis fulva (L.), Buxus megistophylla, Sedum aizoon L., Rubia cordifolia L. Among them, only Hosta plantaginea (Lam.) and Duchesnea indica (Andr.).

The planting area of ground cover plants in the three parks is only 3311 m². The minimum area ratio is 0.0003%, and the maximum is only 0.13%. The ground cover plants are mainly distributed in patches, and the density difference of various vegetation is large. The frequency of only one plot is 28%, while that of the rest is not more than 10%. In a word, shade tolerant ground cover plants are seldom used in Tianjin parks.

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