Species and Distribution Characteristics of Alien Invasive Plants in Garden Greenbelt of Shijiazhuang City

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Abstract [**Objectives**] The paper was to investigate the garden greenbelt in 30 sample plots such as parks, roads, communities, *etc.* in Shijiazhuang City. [**Methods**] The species, abundance and frequency of weeds in the greenbelt of public gardens were recorded through point-line-surface investigation, and typical plants were sampled. [**Results**] There were 56 species of alien invasive plants in garden greenbelts of Shijiazhuang City, belonging to 44 genera and 20 families. In terms of life form, herbaceous plants were absolutely dominant, accounting for 92.8% of the total. The most alien invasive plants were native to America, accounting for 66.1% of the total. In terms of introduction path, the plants introduced artificially and unintentionally accounted for almost half. The species and quantity of alien invasive plants were related to the size of greenbelt area, the length of the build time of the surveyed plot, the composition structure of greenbelt and the level of green management and protection. There was larger distribution of alien invasive plants in the sample plots with large greenbelt area, long build time, herbaceous-dominated greenbelt and low level of green management and protection. Among the 56 alien invasive plants, 3 plants were toxic. From the perspective of invasiveness, the alien invasive plants in the garden greenbelt of Shijiazhuang City could be divided into 5 levels: invasive alien species of malignant consequences, invasive alien species of severe consequences, invasive alien species of partial consequences, invasive alien species of average consequences, and invasive alien species to be observed. [**Conclusions**] This study will provide a reference for the prevention and control of alien plant invasion, and lay a foundation for the prevention and control of existing invasive plants.

Key words Alien invasive plant; Garden greenbelt; Distribution characteristics; Shijazhuang City; Introduction path

1 Introduction

Urban greenbelt is the "lung" of the city, and it can eliminate pollution and purify the air to a certain extent, and provide the functions of viewing and recreation for urban residents. The systematic operation of urban greenbelt is closely related to the image of the city, ecological safety and even the health of residents. With the economic development, the introduction of garden plants becomes more and more frequent, and there is a large proportion of alien species introduced. Due to the instability, openness, fragmentation and vulnerability of urban greenbelt ecosystem, there is a large risk of invasive alien species. The invasion of alien species often affects the naturalness and integrity of urban green landscape, and even destroys the landscape style of the city, causing the destruction of the ecosystem and biodiversity of the invaded area, and bringing huge impacts on the social economy and even the health of residents. It is conducive to better prevention and control of invasive plants by clarifying the distribution of urban alien plants, understanding their invasiveness, and strengthening risk assessment and management, which can avoid their adverse aspects while promoting urban beautification and meeting the landscape needs of citizens. A number of scholars have done related researches on the investigation and risk assessment of alien invasive plants in garden greenbelt. Chen Shuang *et al.* [1] investigated and studied alien invasive plants in urban garden greenbelt in Chongqing; Wang Nanyuan *et al.* [2] conducted ecological risk assessment on alien garden plants in South Dianchi National Wetland Park; Tian Zonglin[3] investigated and evaluated the invasion risk of alien garden plants in Ningxia. However, there have been no reports on the study of invasive alien plants in Hebei Province. Therefore, this paper investigated invasive alien plants in garden greenbelt of Shijiazhuang City, in order to provide a reference for the prevention and control of alien plant invasion and lay a foundation for the prevention and control of existing invasive plants.

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2 Survey sites and methods

2.1 Survey sites From April 2021 to September 2022, a field survey was conducted on weeds in garden greenbelt in the main urban area of Shijiazhuang City. A total of 30 sample plots including 17 parks, 6 communities and 7 roads were investigated (Table 1).

2.2 Survey methods The species, abundance and frequency of weeds (frequency refers to the number of times the plant appears) in the greenbelt of public gardens were recorded through point-line-plane investigation, and typical plants were sampled. In the specific survey, a plot of 1 m × 1 m was taken as a survey unit, in which the occurrence frequency of each weed was recorded as 1, and the vertical projection area of each plant of 1 m^2 was denoted as 1, thus representing plant abundance. In parks and communities, surface survey was mainly adopted, supplemented by point survey. Complete investigation was adopted in small areas, while several areas were randomly selected for detailed investigation in large areas. In other areas, supplementary investigation

was carried out when there were new species. The investigation of roads adopted the transect method, with every 1m as a survey unit, and the species and abundance of weeds were recorded. In this study, the average abundance (that is, Average abundance = Total abundance of the sample plots/Frequency) was used to represent the distribution of alien invasive plants. The larger the average abundance value of a survey unit or a species of plant indicated that the area or the plant had a large area of distribution. Otherwise, the distribution of the survey unit or the plant was more dispersed.

Table 1 Statistics of sample plots for weed survey in garden greenbelt of Shijiazhuang City

Types of sample plots	Distribution of sample plots
Park (17)	Shimen Park, People's Square, Ouyun Park, Chang'an Park, Berlin Park, Century Park, Ping'an Park, Hope Oasis Park, Yuxi Park, Water Park, East Ring Park, Sports Park, Huaibei Park, Friendship Park, Xiqing Park, Rose Park, Tianshan Park
Road (7)	Fanxi Road, Yuhua Road, Huaian Road, Huaizhong Road, Jianshe Street, Zhufeng Street, Zhujiang Road
Community (6)	Dormitory of Water Conservancy Bureau, 3302 Community, Shimen Community, Xinjie Community, Hebei Academy of Governance, Daoxiang Village Park

2.3 Data processing All data were analyzed by Excel software.

3 Results and analysis

According to relevant literature[4-7], weed specimens collected in garden greenbelt were identified. The origin of invasive plants was determined through China's Alien Invasive Species Information System (http://www.iplant.cn/ias/stu), and the list of alien invasive plants in garden greenbelt of Shijiazhuang City was finally determined (Table 2).

3.1 Species composition There were 56 species of alien invasive plants belonging to 44 genera and 20 families, including 22 species in Asteraceae (39.3%), 6 species in Amaranthaceae (10.7%), 4 species in Fabaceae (7.1%), 3 species in Brassicaceae (5.4%), 2 species in Chenopodiaceae, Convolvulaceae, Euphorbiaceae, Solanaceae and Scrophulariaceae (3.6%), 1 species in Nyctaginaceae, Phytolaecaceae, Caryophyllaceae, Geraniaceae, Anacardiaceae, Vitaceae, Malvaceae, Onagraceae, Apocynaceae, Poaceae and Amaryllidaceae (1.8%), respectively. Asteraceae plants accounted for a large proportion, which may be due to the fact that the seeds of Asteraceae are achenes, light in weight and many with crown hairs, which are easy to be spread by wind. Moreover, many Asteraceae plants have strong stress resistance, good adaptability, and strong self-sowing ability, and some can even produce allelochemicals to inhibit the growth of other plants and even cause their death[8]. These biological characteristics make Asteraceae have strong invasive advantages and harmfulness (Table 2).

Among these invasive plants, *Solidago canadensis* L. and *Flaveria bidentis* (L.) O. Kuntzel belong to the second batch of China's alien invasive species list released by the Ministry of Environmental Protection (2010). *Aster subulatus* Michx., *Erigeron canadensis* L., *Erigeron annuus* (L.) Pers. and *Ipomoea purpurea* (L.) Lam. belong to the third batch of China's alien invasive species list released by the Ministry of Environmental Protection (2014). *Phytolacca americana* L. and *Ageratum conyzoides* L. belong to the forth batch of China's alien invasive species list released by the Ministry of Environmental Protection (2016)[9-11].

3.2 Life-form structure Life form is the external manifestation of plant adaptation to the external environment. The life form of alien invasive plants in the garden greenbelt of Shijiazhuang City was composed of trees, shrubs, herbs and vines. In addition to 2 species of trees (*Robinia pseudoacacia* L., *Rhus typhina* L.), 1 species of herb or suffrutex [*Catharanthus roseus* (L.) G. Don], and 1 species of vine [*Parthenocissus quinquefolia* (L.) Planch.], the other 52 plants were herbs, accounting for 92.9% of the total species. Among herbs, there were 41 species of annual or biennial herbs, accounting for 73.2% of the total herbs (Table 2).

3.3 Origin analysis Based on the analysis of the origin of alien invasive plants, the results showed that there were 37 species native to America (66.1%), 4 species native to Europe, 5 species native to West Asia and India, 4 species native to Africa, 1 species native to North Africa, Central Asia, West Asia and Europe, 2 species native to Western Asia and Europe, and 2 species native to Europe and the Mediterranean, and the origin of 1 species was unknown (Table 2).

3.4 Introduction path In Shijiazhuang City, 30 alien invasive plants were introduced artificially, accounting for 53.6% of the total, which was the main introduction path of invasive plants. Alien species were intentionally introduced due to varying purposes. *Medicago sativa* L. and *Melilotus officinalis* (L.) Pall. were introduced as forage; *Oenothera biennis* L., *I. purpurea*, *Coreopsis lanceolata* L., *Gazania rigens* Moench, *Tagetes erecta* L., *etc.* were introduced as ornamental plants; *Abutilon theophrasti* Medicus and *Ricinus communis* L. were introduced as cash crops; *P. americana* and other species were introduced as medicinal plants. Many species escaped into the wild during cultivation, existed as weeds, and developed into invasive species under appropriate conditions. There were 26 species (46.4%) unintentionally introduced, accounting for 46.4% of the total, such as *Amaranthus viridis* L., *etc.* that were brought in with international imports of agricultural products and goods, *E. canadensis*, *E. annuus*, *etc.* that were introduced by human vehicles, *Veronica persica* Poir., *etc.* that were introduced along with plants, especially the introduction of garden plants (Table 2).

Table 2 List of alien invasive pants in garden greenbelt of Shijiazhuang City

Family name	Species name	Origin	Life form	Introduction path	Invasion level
Chenopodiaceae	*Chenopodium ficifolium* Smith	Europe	Annual herb	a	IV
	Chenopodium glaucum L.	Unknown	Annual herb	a	IV
Amaranthaceae	*Amaranthus tricolor* L.	India	Annual herb	a	III
	Amaranthus blitum Linnaeus	Tropical America	Annual herb	a	II
	Amaranthus cruentus Linnaeus	Central America	Annual herb	b	III
	Amaranthus polygonoides L.	Southwestern United States and Mexico	Annual herb	a	II
	Amaranthus retroflexus L.	Tropical America	Annual herb	b	I
	Amaranthus viridis L.	South America	Annual herb	a	II
Nyctaginaceae	*Mirabilis jalapa* L.	Tropical America	Annual herb	b	II
Phytolaecaceae	*Phytolacca americana* L.	North America	Perennial herb	b	II
Caryophyllaceae	*Myosoton aquaticum* (L.) Moench	Europe	Perennial herb	a	IV
Brassicaceae	*Capsella bursa-pastoris* (L.) Madic.	West Asia and Europe	Annual or biennial herb	a	IV
	Cardamine flexuosa With.	Europe	Annual or biennial herb	a	IV
	Coronopus didymus (L.) J. E. Smith	South America	Annual or biennial herb	a	IV
Fabaceae	*Melilotus officinalis* (L.) Pall.	West Asia to Southern Europe	Biennial herb	b	IV
	Medicago sativa L.	West Asia	Perennial herb	b	IV
	Robinia pseudoacacia L.	North America	Deciduous tree	b	III
	Trifolium repens L.	North Africa, Central Asia, West Asia and Europe	Perennial herb	b	II
Geraniaceae	*Geranium carolinianum* L.	North America	Annual herb	a	II
Eupborbiaceae	*Euphorbia maculata* L.	North America	Annual herb	a	III
	Ricinus communis L.	East Africa	Annual herb	b	II
Anacardiaceae	*Rhus typhina* L.	North America	Deciduous shrub or small tree	b	III
Vitaceae	*Parthenocissus quinquefolia* (L.) Planch.	Eastern North America	Woody vine	b	V
Malvaceae	*Abutilon theophrasti* Medicus	India	Annual herb	b	III
Onagraceae	*Oenothera biennis* L.	Eastern North America	Annual or biennial herb	b	II
Apocynaceae	*Catharanthus roseus* (L.) G. Don	Madagascar	Herb or subshrub	b	III
Convolvulaceae	*Ipomoea nil* (L.) Roth	South America	Annual herb	b	II
	Ipomoea purpurea Lam.	America	Annual herb	b	I
Solanaceae	*Datura stramonium* L.	Mexico	Herb or subshrub	b	II
	Physalis minima L.	Probably tropical America	Annual herb	a	IV
Scrophulariaceae	*Veronica persica* Poir.	West Asia	Annual or biennial herb	a	III
	Veronica polita Fries	West Asia	Annual or biennial herb	a	IV
Asteraceae	*Ageratum conyzoides* L.	Tropical America	Annual herb	b	I
	Bidens bipinnata L.	America	Annual herb	a	III
	Centaurea cyanus L.	Europe	Annual or biennial herb	b	V
	Coreopsis lanceolata L.	the United States	Annual herb	b	III
	Cosmos bipinnatus Cav.	Mexico and southwestern United States	Annual or perennial herb	b	V
	Eclipta prostrata (L.) L.	America	Annual herb	a	IV
	Erigeron bonariensis L.	South America	Annual or biennial herb	a	II
	Erigeron canadensis L.	North America	Annual herb	a	I
	Erigeron annuus (L.) Pers.	North America	Annual or biennial herb	a	I
	Flaveria bidentis (L.) O. Kuntzel	South America	Annual herb	a	I
	Gaillardia pulchella Foug.	America	Annual herb	b	V
	Galinsoga parviflora Cav.	South America	Annual herb	a	II
	Gazania rigens Moench	South Africa	Perennial root herb	b	V
	Helianthus tuberosus L.	North America	Perennial herb	b	IV
	Rudbeckia laciniata L.	North America	Perennial herb	b	V
	Solidago canadensis L.	North America	Perennial herb	b	I
	Sonchus asper (L.) Hill	Europe and the Mediterranean	Annual herb	a	IV
	Sonchus oleraceus L.	Europe and the Mediterranean coast	Annual or biennial herb	a	IV
	Aster subulatus Michx.	North America	Annual herb	a	I
	Tagetes erecta L.	North America	Annual herb	b	V
	Tagetes patula L.	Mexico	Annual herb	b	III
	Zinnia elegans Jacq.	Mexico	Annual herb	b	V
Poaceae	*Chloris virgata* Sw.	Africa	Annual herb	a	IV
Amaryllidaceae	*Hippeastrum rutilum* (Ker-Gawl.) Herb.	South America	Perennial herb	b	V

Note: a. Unintentional introduction; b. Artificial introduction; I. Invasive alien species of malignant consequences; II. Invasive alien species of severe consequences; III. Invasive alien species of partial consequences; IV. Invasive alien species of average consequences; V. Invasive alien species to be observed.

3.5 Hazards Among the 56 alien invasive plants, 3 species were toxic, namely *Euphorbia maculata* L., *Datura stramonium* L. and *P. americana*. *E. maculate* is listed as one of the most common and least easily eradicated weeds in farmland of North America, and the whole plant is poisonous. The whole plant of *D. stramonium* contains alkaloids, which can cause hallucination, dizziness and paralysis, and has strong toxicity to humans and animals, especially fruits and seeds. The whole plant of *P. americana* is toxic, and the root and fruit are the most toxic. Because its roots resemble ginseng, it is often mistakenly taken as ginseng, which can lead to severe vomiting or dry choking, stomach burning, abdominal convulsions, diarrhea, and even heart paralysis.

According to the classification of invasive plants by Ma Jinshuang[12], the alien invasive plants in the garden greenbelt of Shijiazhuang City could be divided into 5 levels: Level 1, invasive alien species of malignant consequences (8 species), referring to the species that had caused great loss and serious impact on economic or ecological benefits at the national level, and had invaded more than one natural geographical area, accounting for 14.3% of the total; Level 2, invasive alien species of severe consequences (13 species), referring to the species that caused significant losses and impacts on economic and ecological benefits at the national level and were distributed in at least one physical geographical area, accounting for 23.2% of the total; Level 3, invasive alien species of partial consequences (11 species), referring to the species that had a range of more than one physical geographical area and caused partial consequences, but did not cause large-scale consequences at the national level, accounting for 19.6% of the total; Level 4, invasive alien species of average consequences (15 species), referring to the species that had unobvious harm according to their biological characteristics and were difficult to form a new trend of development regardless of relatively wide or narrow geographical distribution, accounting for 26.8% of the total; Level 5, invasive alien species to be observed, referring to the species that were not well understood, or that had appeared for a short time, recently reported and not well understood to determine future trends, accounting for 1.61% of the total (Table 2).

3.6 Distribution characteristics

3.6.1 Spatial distribution characteristics. After investigation and statistics, there were at least 4 species and at most 24 species of invasive alien plants in each sample plot. For residential communities, this may be related to the size of greenbelt area and the length of the build time of the surveyed plot. Generally, the longer the build time and the larger the area, the more the species of alien invasive plants, and vice versa. For example, Shimen Community had the largest number of species (24) because of long built time (22 years), large area and high green rate; the adjacent Xinjie Community had only 5 species of invasive plants due to short built time (8 years) and small area; similarly, Daoxiang Village Park had only 4 alien invasive plants due to its short built time (Table 3).

Table 3 Statistics on the distribution of alien invasive plants in the sample plots

No.	Sample plot	Species number	Total frequency times	Total abundance dm^2	Average abundance dm^2/times
1	Dormitory of Water Conservancy Bureau	11	49	2 701	55.1
2	3302 Community	14	136	2 157	15.9
3	Shimen Community	24	117	1 109	9.6
4	Xinjie Community	5	15	40	2.7
5	Hebei Academy of Governance	12	96	135	1.4
6	Daoxiang Village Park	4	36	182	5.1
7	People's Square	11	79	243	3.1
8	Shimen Park	13	128	247	1.9
9	Ouyun Park	12	77	530	6.9
10	Chang'an Park	10	50	148	3.0
11	Berlin Park	15	98	165	1.7
12	Century Park	11	32	75	2.3
13	Ping'an Park	6	12	17	1.4
14	Hope Oasis Park	10	41	89	2.2
15	Yuxi Park	12	31	185	6.0
16	Water Park	10	35	291	8.3
17	East Ring Park	7	26	240	9.2
18	Sports Park	11	43	195	4.5
19	Huaibei Park	10	48	179	3.7
20	Friendship Park	8	75	3 264	43.5
21	Xiqing Park	5	19	1 113	58.6
22	Tianshan Park	5	18	31	1.7
23	Rose Park	8	45	545	12.1
24	Jianshe Street	8	88	173	2.0
25	Yuhua Road	9	62	335	5.4
26	Fanxi Road	10	68	202	3.0
27	Huaizhong Road	6	13	45	3.5
28	Huaian Road	5	8	9	1.1
29	Zhufeng Street	7	67	921	13.7
30	Zhujiang Road	10	45	116	2.6

The situation of roads was slightly different. Among the 7 roads surveyed, Huaizhong Road and Huaian Road had the lowest number of species, with 6 and 5 species, respectively. The number of invasive alien plant species in the other 5 roads varied from 7 to 10 species. There was also a significant difference in the total frequency of occurrence, with 13 times in Huaizhong Road, 8 times in Huaian Road, and 45 to 88 times in the remaining 5 roads (Table 3). The number and occurrence frequency of alien invasive plants may be related to the green structure on both sides of the road, because trees and shrubs were the absolute dominant green structures in Huaizhong Road and Huaian Road, while the area of the herb layer in the other roads was relatively large. Since the alien invasive plants were mainly herbs, the required sunlight and space can be better obtained by growing and spreading in the herbaceous layer. However, in the greenbelt structure dominated by trees and shrubs, the living space of invasive herbs was limited due to the height advantage of trees and shrubs, and their distribu-

tion species and occurrence frequency were significantly reduced. In terms of the abundance of invasive alien plants, the total abundance may be related to the total area of the sample plot, because the area of sample plots varied greatly, and it was appropriate to use the average abundance to represent the distribution of invasive alien plants in each sample plot. The average abundance may be related to the level of greening management in the sample plot. Generally, management in place and timely weeding would not lead to the spread of weeds in large areas, but only sporadic; and large overgrown green areas are usually inaccessible green areas.

3.6.2 Quantitative distribution characteristics. There were differences in the occurrence frequency and abundance of 56 alien invasive plants in garden greenbelt of Shijiazhuang. According to these differences, all plants were divided into 7 groups (Table 4).

Table 4 Statistics of abundance and frequency of alien invasive plants

Group	Plant	Frequency times	Total abundance dm^2	Average abundance dm^2/times
Group 1	*Erigeron canadensis* L.	366	1 526	4.17
	Sonchus oleraceus L.	237	812	3.43
	Chenopodium ficifolium Smith	176	647	3.68
	Erigeron bonariensis L.	112	1 625	14.51
	Veronica persica Poir.	113	1 419	12.56
	Capsella bursa-pastoris (L.) Madic.	96	2 422	25.23
	Trifolium repens L.	80	1 052	13.15
Group 2	*Robinia pseudoacacia* L.	66	134	2.03
	Sonchus asper (L.) Hill	64	103	1.61
	Amaranthus viridis L.	60	128	2.13
	Aster subulatus Michx.	49	95	1.94
	Veronica polita Fries	30	117	3.90
	Eclipta prostrata (L.) L.	21	70	3.33
	Bidens bipinnata L.	12	79	6.58
Group 3	*Amaranthus blitum* Linnaeus	8	17	2.13
	Ipomoea nil (L.) Roth	6	8	1.33
	Physalis minima L.	6	14	2.33
	Parthenocissus quinquefolia (L.) Planch.	6	27	4.50
	Galinsoga parviflora Cav.	5	10	2.00
Group 4	*Cardamine flexuosa* With.	14	1 107	79.07
	Myosoton aquaticum (L.) Moench	73	3 510	48.08
	Amaranthus polygonoides L.	3	216	72.00
Group 5	*Datura stramonium* L.	3	12	4.00
	Centaurea cyanus L.	3	13	4.33
	Gazania rigens Moench	3	27	9.00
	Rhus typhina L.	2	21	10.50
	Erigeron annuus (L.) Pers.	2	22	11.00
	Zinnia elegans Jacq.	3	14	4.67
	Cosmos bipinnatus Cav.	2	13	6.50
	Phytolacca americana L.	2	20	10.00
	Mirabilis jalapa L.	4	25	6.25
	Medicago sativa L.	2	10	5.00
Group 6	*Chenopodium glaucum* L.	4	9	2.25
	Flaveria bidentis (L.) O. Kuntzel	1	6	6.00
	Solidago canadensis L.	1	4	4.00
	Melilotus officinalis (L.) Pall.	1	3	3.00
	Ageratum conyzoides L.	1	5	5.00
	Abutilon theophrasti Medicus	4	8	2.00
	Amaranthus cruentus Linnaeus	3	5	1.67
	Amaranthus retroflexus L.	3	8	2.67
	Amaranthus tricolor L.	3	3	1.00
	Euphorbia maculata L.	2	8	4.00
	Coreopsis lanceolata L.	1	8	8.00
	Rudbeckia laciniata L.	1	3	3.00
	Helianthus tuberosus L.	1	6	6.00
	Ricinus communis L.	1	5	5.00
	Ipomoea purpurea Lam.	2	3	1.50
	Chloris virgata Sw.	2	6	3.00
	Catharanthus roseus (L.) G. Don	1	2	2.00
	Hippeastrum rutilum (Ker-Gawl.) Herb.	1	2	2.00
Group 7	*Gaillardia pulchella* Foug.	1	1	1.00
	Tagetes erecta L.	1	1	1.00
	Geranium carolinianum L.	1	1	1.00
	Oenothera biennis L.	1	1	1.00
	Tagetes patula L.	1	1	1.00
	Coronopus didymus (L.) J. E. Smith	1	1	1.00

Group 1 included 7 species of plants, all of which were unintentionally introduced except for *Trifolium repens* L., and their distribution frequency and total abundance were the highest, indicating that these plants were not only widely distributed but also abundant, and had formed population advantages in some areas, having a greater impact on green landscape due to strong ability to spread and diffuse. *E. canadensis*, *Sonchus oleraceus* L., *Erigeron bonariensis* L., *T. repens*, *Chenopodium ficifolium* Smith and *Capsella bursa-pastoris* (L.) Madic., were widely distributed in the region and could be seen almost everywhere, with certain distribution in parks, communities and roads. *T. repens* may be mostly used as a ground cover plant, and the area that existed most in the form of weeds was the greenbelt after the change of ground cover plant species. New ground cover plants were usually mixed with scattered *T. repens* or grew in small patches in a small area. At present, *V. persica* is mainly distributed in Ouyun Park, Rose Park and Zhufeng Street in the urban area, showing a trend of spreading and growing in local areas. The average abundance of *C. ficifolium*, *E. conardensis* and *S. oleraceus* was small, indicating that they were distributed in multiple points but rarely in patches. The average abundances of *E. bonariensis*, *V. persica*, *C. bursa-pastoris* and *T. repens* were all over 10, indicating that these plants had lamella distribution in greenbelts.

Group 2 included 7 species, all of which were unintentionally introduced except *Robinia pseudoacacia* L. Their occurrence frequency and total abundance were high, indicating that they were distributed in multi-point and small patches in local areas, and formed certain population dominance, which was relatively destructive to the landscape.

Group 3 consisted of 5 plants, including *Amaranthus blitum* Linnueus, *Ipomoea nil* (Limaeus) Roth, *Physalis minima* L., *P. quinquefolia*, and *Galinsoga parviflora* Caw. Their distribution frequency was 5 – 8 times, and the total abundance was 8 – 27 dm^2, indicating that they were only scattered in individual sample plots. Although they had successfully colonized in some areas, they did not have a great impact on the landscape. Among these 5 plants, the others were unintentionally introduced except for *I. nil* and *P. quinquefolia*.

Group 4 included 3 species of plants, all of which were unintentionally introduced. It is noteworthy that the distribution area of the 3 plants was small, but they were distributed in a large area in different sample plots, and the average abundance of their distribution was as high as 48.08 – 79.07 dm^2. *Myosoton aquaticum* (L.) Moench occurred in 5 sample plots, but only showed large-area multiple-point distribution in Friendship Park, and had very small distribution in the other 4 sample plots. *Cardamine flexuosa* With. was only found in 3 sample plots, and was distributed in large areas only in Xiqing Park, but was occasionally seen in the other 2 sample plots. *Amaranthus polygonoides* L. was only distributed in Water Park, with small range of distribution, and had not spread over a large area. These 3 plants had relatively narrow range of distribution, and were widely distributed in only a few areas, which may be related to their biological characteristics. All these 3 plants are propagated by seeds, and seed transmission is generally performed in a short distance. It may also be due to the lack of human interference for many years, coupled with the strong adaptability of the plant itself, so there was a large area of growth and spread of the species.

Group 5 included 10 plants, whose distribution frequency was 2 – 4 times and the total abundance was 10 – 27 dm^2, indicating that there were only small patches of distribution in different sample plots. Except for *E. annuus* which was unintentionally introduced, the other 9 plants were introduced artificially, and the escape phenomenon of their individual plant may have a certain relationship with the intentional spread of humans.

Group 6 included 18 species, whose distribution frequency ranged from 1 to 4 times and the abundance ranged from 2 to 9 dm^2, indicating that these species were scattered and distributed in small amounts only in individual sample plots. Among the 18 species, 5 species were introduced unintentionally and 13 species were introduced artificially. There was a certain degree of contingency for the distribution of these plants as weeds in green areas.

Group 7 consisted of 6 plants with the distribution frequency and abundance of 1. *Coronopus didymus* (L.) J. E. Smith and *Geranium carolinianum* L. were introduced unintentionally, while the rest were introduced artificially. The extremely low frequency and abundance indicated that the distribution of these plants was highly accidental.

4 Discussion and conclusions

In summary, a total of 56 alien invasive plants were found in this survey. Among them, Asteraceae plants were the most numerous, with 22 species, and herbaceous plants were absolutely dominant, accounting for 92.8% of the total. The most alien invasive plants were native to America, accounting for 66.1% of the total. In terms of introduction path, the plants introduced artificially and unintentionally accounted for almost half. The species and quantity of alien invasive plants were related to the size of greenbelt area, the length of the build time of sample plots, the composition structure of greenbelt and the level of green management and protection.

A number of scholars have done relevant researches on invasive alien plants in Hebei Province. Shi Qing *et al.*[13-14] studied the alien invasive plants in the Beijing – Tianjin – Hebei region; Long Ru *et al.*[15] made statistics on alien invasive plants in Hebei Province; Wu Yansheng *et al.*[16], Song Jialin *et al.*[17] and Chen Hao[18] studied the alien invasive plants in Xingtai Plain, Qingyuan District of Baoding and Qinhuangdao City, respectively; Xu Wenchao[19] discovered the distribution of an alien invasive plant in Hebei Province, *Sicyos angulatus* L. In terms of family composition and origin, Asteraceae and American origin were dominant, and in terms of life forms, herbs, especially annual or biennial herbs, were dominant[13-18], which is in agreement with the results of this study.

There are regional differences in the distribution types and quantities of invasive alien plants among regions[19-21], and the same plant will have different invasion manifestations in different regions. The classification of invasive alien plants in this study was based on relevant data[12], and the results were mainly based on various literature reports and preliminary investigation results in local areas. For the invasive risk assessment of invasive alien plants in this study, it is also necessary to establish a risk assessment system suitable for the invasive situation of local invasive plants, the introduction process of invasive alien species and the treatment methods of harmful species, and carry out further in-depth research, to effectively manage and dispose of existing invasive alien species in the area, and identify and evaluate the introduced species, thus effectively prevent the invasion of alien plants.

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