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Research Paper

Species diversity and performance assessment of trees in domestic gardens

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HIGHLIGHTS

- We studied species diversity and tree performance in domestic gardens in Hong Kong.
- Tree species composition was dominated by a small number of popular exotic species.
- Tree species distribution was strongly associated with some habitat-tree variables.
- Indicators of poor tree performance correlated with tree position and confinement.
- Findings could enhance contribution of domestic gardens to urban biodiversity.

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ABSTRACT

Domestic gardens, as an important component of urban green infrastructure, could make significant contributions to urban biodiversity. This study evaluated species composition, floristic diversity, amenity-ecological characteristics, habitat condition, and performance of trees in domestic gardens in urban Hong Kong. The 1501 individual trees belonged to 72 species, 61 genera and 36 families, with domination by a small cohort of popular species. Tree composition skewed heavily toward exotic species count (81.9%) and tree count (91.1%). The most prominent amenity-ecological attributes were fast growth and establishment and interesting tree form and foliage, accounting respectively for 38, 32 and 27 species. Nonmetric Multidimensional Scaling (NMDS) indicated strong association between species distribution in domestic gardens and habitat-tree variables, such as tree density, tree aggregation, species aggregation, lots with trees and house lots. Redundancy Analysis (RDA) showed positive correlation ($p < 0.05$) between tree and species counts and lot frontage and garden depth. Detrended Correspondence Analysis (DCA) identified 16 species with relatively widespread presence in moderate or severe structural damage groups; and 22 species with very poor or poor overall condition. RDA further demonstrated positive correlation ($p < 0.05$) between structural damage and overall condition, and tree position and confinement type. The contribution of domestic gardens in the urban greening program could be improved with appropriate incentives, and be integrated into a comprehensive landscape plan. The management implications with reference to preservation and enhancement of garden trees could be applied to south China and other cities.

1. Introduction

Urban green infrastructure (UGI) has been widely studied for its positive role in environmental improvement, esthetic enhancement, ecological and biodiversity enrichment, and economic, social and health benefits (Konijnendijk, Ricard, Kenney, & Randrup, 2006). Including parks, public green space, allotments, green corridors, roadside trees, urban forests, roof and vertical greening, and private domestic gardens, UGI has been treated as fundamental components of the urban landscape (Cameron et al., 2012). In some cities, these green enclaves have been integrated into sustainable and ecosystem-based plans and urban biodiversity initiatives (Gaffin, Rosenzweig, & Kong, 2012; Jones, Hole, & Zavaleta, 2012).

Domestic gardens, defined as the private spaces adjacent to or surrounding dwellings comprising lawns, ornamental and vegetable plots, ponds, paths, patios, and temporary buildings such as sheds and greenhouses, are deemed as an important component of urban green infrastructure (Gaston, Smith, Thompson, & Warren, 2005; Loram, Tratalos, Warren, & Gaston, 2007; Stewart et al., 2009; Thompson, Austin, Smith, Warren, Angold, & Gaston, 2003).

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In the UK, 87% of households have autonomy over their domestic gardens, which contributed 35–47% of the total urban green space (Loram et al., 2007). In Dunedin, New Zealand, domestic gardens constitute over 50% of urban green lands (Mathieu, Freeman, & Aryal, 2007). In the USA, 78% of households undertake some gardening activities in private green spaces (Kiesling & Manning, 2010). Although small in individual size, the aggregate areas of domestic gardens in the studied cities could contribute to urban green infrastructure (Gaston, Fuller, Loram, MacDonald, Power, & Dempsey, 2007; Smith, Thompson, Warren, & Gaston, 2010; Thompson, Hodgson, Smith, Warren, & Gaston, 2004). Despite the large aggregate size, domestic gardens are seldom included in the design and management of sustainable urban biodiversity initiatives by local governments and relevant authorities (Gaston et al., 2005; Thompson et al., 2003), largely because they are either privately owned or rented. Some studies have testified the importance of domestic gardens to urban biodiversity in temperate-latitude cities in Europe and North America (Smith et al., 2010). Reliable information on domestic gardens is lacking, mainly due to difficulties in acquiring systematic data from the fragmented and often inaccessible resource base (Cameron et al., 2012; Loram et al., 2007).

Hong Kong is an ultra-compact city in East Asia, characterized by difficult terrain and grave shortage of land easily developed, resulting in high-rise, high-density and multiple-intensive landuse (Jim, 2000). The overwhelming majority of the 7.15 million population dwell in densely packed and high-rise public and private housing estates (Census and Statistics Department, 2013). Only a tiny proportion of residents live in houses with private gardens in neighborhoods for the high and upper-middle income groups.

Despite widespread recognition of the significance of domestic gardens to urban biodiversity (e.g. Smith, Thompson, Hodgson, Warren, & Gaston, 2006; Thompson et al., 2004), almost no study has been attempted in Hong Kong. Trees at public roadside and green spaces have been studied (e.g. Jim, 1999; Jim & Chen, 2011), but those in private residential properties have been largely ignored. Due to multiple ownership and hence a diverse product of many individual decisions and actions, private trees present a fertile research realm. Housing type and density influence the proportion and quality of available green space (Cameron et al., 2012; Smith et al., 2006; Thompson et al., 2003), and environmental and cultural differences may influence residential tree characteristics (Jim, 1993).

This study addressed such themes, namely tree species diversity and performance in the gardens of private residences, through a detailed study of domestic garden trees in a low-density residential neighborhood in Hong Kong. The study objectives were to: (1) assess species composition and diversity, and their amenity characteristics in domestic gardens in urban Hong Kong; (2) evaluate tree performance and impacts of habitat conditions on tree performance; (3) elucidate the fundamental determinants of the observed tree diversity and patterns; and (4) apply the findings to interpret management implications for landscape trees in domestic gardens in urban Hong Kong and other tropical cities.

2. Study area and methods

2.1. Study area

Hong Kong is located on the southeastern coast of China, and consists of a mainland part (New Territories and Kowloon Peninsula), Hong Kong Island, and over 100 small islands, with a total land area of 1104 km^2. The rugged topography confines built-up areas to merely 22% of the land area, accommodating about 90% of the 7.15 million population (Census and Statistics Department, 2013). The humid-subtropical climate is greatly affected by the large-scale monsoon system, with a hot-wet summer (May–August) and a cool-dry winter (November–February). The mean annual temperature is about 23.3 °C and annual rainfall 2398 mm (1981–2011), with three-quarters falling in May to September (Hong Kong Observatory, 2013).

The study was carried out in the Kowloon Tong Garden Estate, a residential area for the high-income group situated in Kowloon Peninsula in Hong Kong. The 23.29 ha is occupied by European-style single-family detached houses, public open spaces and tree-lined avenues. The Estate is one of the few remaining low-density residential developments endowed with domestic gardens. Reflecting the history of the British Empire, it was built in phases from 1922 to 1929 to cater to the rising affluence of a small group of Chinese inhabitants who were then not allowed to live in the exclusive

Table 1
Summary of domestic garden tree survey at 23 sampled roads in Kowloon Tong.

Road name	Road code	Road frontage (m)	Road width (m)	House lots (no.)	Lots with trees (no.)
Cambridge Road	R1	800	12.5	17	13
Cumberland Road	R2	1392	12.5	45	32
Devon Road	R3	308	12.5	10	8
Dorset Crescent	R4	410	12.5	11	11
Dumbarton Road	R5	90	18.5	1	1
Durham Road	R6	540	12.5	5	3
Essex Crescent	R7	655	12.5	11	11
Hampshire Road	R8	236	12.5	4	4
Hereford Road	R9	740	13.5	5	5
Kent Road	R10	724	12.5	24	22
La Salle Road	R11	1660	20	20	17
Lancashire Road	R12	640	15	11	5
Moray Road	R13	236	7.5	3	2
Norfolk Road	R14	428	11	9	8
Oxford Road	R15	860	12.5	21	17
Rutland Quadrant	R16	590	12.5	8	7
Selkirk Road	R17	236	7.5	4	3
Somerset Road	R18	464	12.5	15	13
Stafford Road	R19	520	13	23	21
Suffolk Road	R20	516	16	12	9
Waterloo Road	R21	2050	30	41	28
Wiltshire Road	R22	238	11	9	7
York Road	R23	390	11	14	14
Total	–	14,723	–	323	261
Average	–	640	13.5	14	11