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Zoological Research

Impacts of Environmental Factors on the Structure Characteristics of Avian Community in Shanghai Woodlots in Spring

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Abstract: From March to May, 2004, we selected 8 typical parks or green lands in Shanghai downtown as the study sites to conduct a ornithological research. During this study, total 55 species of birds were recorded, which included 31 resident and 24 migratory species. With statistics methodology, we analyzed the avian communities with 10 major environmental factors covering the park area, water percentage, vegetation species, canopy cover, shrub cover, grass cover, hill number, location condition, human quantity, path width, the study results indicated that: (1) the following 7 environmental factors were important to impact the structures of the avian community, they were park area, vegetation species, shrub coverage, grass coverage, hill number, location condition of the parks and path width; (2) the avian community of theses urban parks tended to deteriorate in the bird number and diversity; the man-made lake which was currently promoted in the park designing and planning process would not be good to attract the birds.

Key words: Urban avian community; Bird diversity; Key environmental factor; Shanghai park

环境因子对上海城市园林春季鸟类群落结构特征的影响

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摘要: 2004年3—5月, 对上海8个园林绿地的春季鸟类做了研究。在调查中共观察到55种鸟类, 其中留鸟31种, 候鸟24种。运用回归与相关统计分析方法分析了鸟类群落结构和分布特征与8个园林绿地的公园面积、水体比例、植被种数、乔木层盖度、灌木层盖度、草本层盖度、地形坡度异质性、临主干道状况、人流量、行道宽度10项环境指标的关系。结果表明: (1)公园面积、植被种数、灌木层盖度、草本层盖度、地形坡度异质性、临主干道状况、行道宽度等7个因子在影响园林鸟类群落结构和分布中起关键性作用; (2)上海城市鸟类数量、多样性呈单一化趋势, 而且公园绿地内大面积水体等建设方案并不利于鸟类的栖息。

关键词: 鸟类群落; 多样性; 关键环境因子; 城市园林; 上海
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Shanghai is one of the largest cities in China and has been developing quickly during the last decade. The total area of parks and green lands is 890 ha, occupying 1.9% of the downtown area, and comprising 1.15 ha for each inhabitant (Huang et al, 1993). Fortunately, because the Shanghai government committed

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itself to make Shanghai an eco-friendly city, more and more new parks and green lands have been built. Now there are more than 70 parks in the downtown area (Che & Song, 2002), most of the ecological functions of these parks are based on artificial environmental features and microhabitats (Yosihiro & Chobei, 1999; Yang, 1995). However, since over 9,100,000 people live in the downtown region which has a comparatively small area of 670 km^2, the conflict between humans and wildlife, especially the birds, is significant (Shanghai Agriculture and Forestry Administration, 2004).

Urban avian community studies have developed quickly in recent years (Esteban & Jukka, 2001), most of them based on the urban land use policy were conducted at the landscape or regional scale, many have concentrated on how habitat structure affects the distribution of birds (Almo, 1997; Esteban & Jukka, 2001; Mark et al, 2003). Previous studies have shown that high bird densities of only a few species occur in urban areas when compared to natural areas, and that species composition and diversity changes as the degree of urbanization increases (Blair, 1996).

Urban woodlots habitat features may affect bird community structures (Andrew & Raymond, 2000). Many researchers have measured the scale at which birds respond to structure in urban woodlots (Jamie et al, 2003; Nancy, 1987), few such studies have been carried out in Shanghai, which is of the unique characters of urbanization development. From March to May, 2004, we undertook an ecological study on birds in 8 selected parks and green lands in Shanghai downtown, the objectives of our study were (1) to determine which environmental factors affect the structure of avian community, and (2) to develop recommendations for the design and management of urban woodlots as high quality habitat for urban birds.

1 Methods

1.1 Study area

Shanghai downtown is located in the central east coastal China (E121°26′, N31°12′). It's hot and rainy in summer, cold and moist in winter. The annual rainfall is 1 048 – 1 138 mm, average air temperature is 15.7 ℃, the average sunlight time is 1 868 hours, the frost-free period is 223 – 235 days, the relative humidity is 77% – 83% (Ge et al, 1999).

The great mass of vegetation species selected in the parks building is evergreen species and deciduous trees (camphor tree *Cinnamomun camphcra*, lotus Magnolia *Magnolia grandiflora*, dawn redwood *Metasequoia glyptostroboides* et al.), ornamental shrub (Chinese box *Buxus microphylla* var. *sinica* et al.) and the large-area lawns and man-made ponds appeared frequently in new built parks.

In spring, we can get the maximum of the abundance of birds in Shanghai downtown (Huang et al, 1993), this is why we selected eight parks or public green lands (3 – 140 ha) built at different times (Fig. 1) in this season. Since the objective of our study was

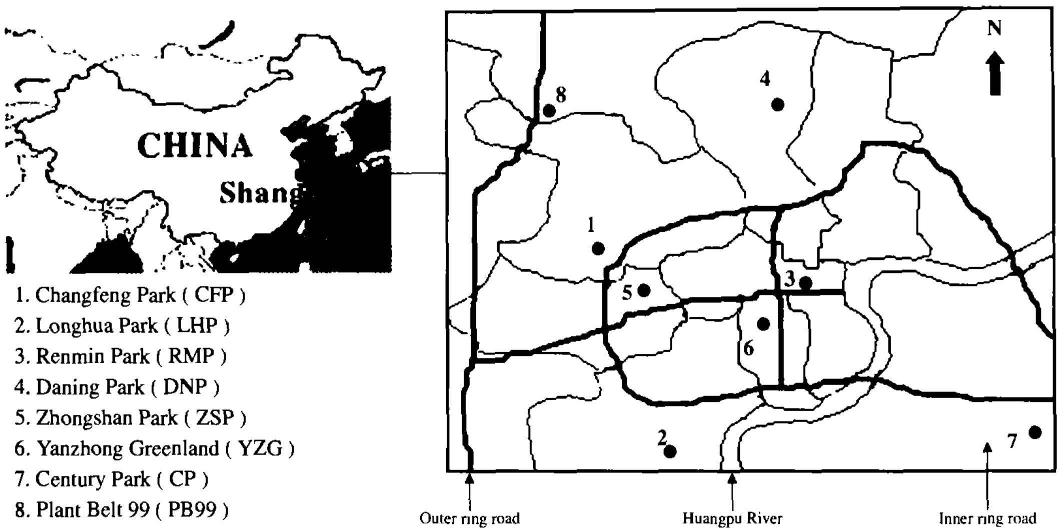

Fig. 1 Study sites selected in Shanghai downtown

to evaluate Shanghai downtown parks and green lands for urban birds, the woodlots far from the city and several special woodlots of the zoo and botanical park were not selected.

1.2 Bird surveys

All bird counts were made between 06:00 – 10:00 and 16:00 – 18:00 during weekdays from March to May 2004, in good weather only. We used a zigzag route that went through most of the woodlands in the chosen survey areas. A team of four or five people counted the birds in the each park over a period of 6 hours (Chen et al, 2002a, b; Jukka, 1999; Mark & Holling, 2000). Each park was thoroughly and systematically searched twice. We recorded the number and species of the birds, except those flying overhead and domestic ones such as pigeons, using binoculars, GPS, field ruler, field guides and other important articles about the bird in Shanghai for species identification (Mackinnon et al, 2000; Tang et al, 2003; Huang et al, 1993).

1.3 Environmental variables

Referring to the published information in urban woodlots, we selected ten environmental factors (Chen et al, 2002b; Esteban, 2002; Jamie et al, 2003; Nancy, 1987; Raymond et al, 1998; Wang et al, 2004). These are listed in Tab. 1. In order to make a thorough assessment, four surveyors were involved in the collection of data on environmental factors.

Tab. 1 Environmental variable and their description

Variable	Unit	Description
Park area (PA)	ha	Park area
Water percentage (WP)	%	The water surface percent in the park (Water area/Park area)
Vegetation species (VS)	Species	Vegetation species number
Canopy cover (CC)	%	Divide the park into several parts with similar area and assess the average canopy cover
Shrub cover (SC)	%	Divide the park into several parts with similar area and assess the average shrub cover
Grass cover (GC)	%	Divide the park into several parts with similar area and assess the average grass cover
Hill number (HN)	Range 1 to 5	Five relative classes: '1' means few hills (only 1 or none); '2' means 2 – 4 hills; '3' means 5 – 7 hills; '4' means 8 – 10 hills; '5' means more than 10 hills
Location condition (LC)	Range 1 to 5	Five relative classes: '1' means the site of park is close to noisy roads or tall buildings, '5' means quiet and open situation
Human quantity (HQ)	ind./(ha·d)	Human (park visitors) number
Path width (PW)	m	Average width of all the paths in each park

1.4 Data analysis

We worked out the following four indices to describe the avian community in each park: total bird species, total bird number, bird density, bird diversity (Shannon & Weiner Index).

In order to understand how the environmental factors impacted on the bird community, we needed to choose key factors without strong correlation to each other, in order not to violate the assumption of co-linearity necessary for regression analysis. During the process, we used Pearson correlation analysis to determine the correlation between the ten environmental variables. Those factors with a strong correlation ($P < 0.01$) were tested using multiple regression analysis; the others were tested by general regression analysis. SPSS 11.0 was used for all the statistical work (Lu, 2000).

2 Results

2.1 Avian community characteristics

We counted 55 species of birds, including 31 residents and 24 migrants (Tab. 2).

We found that the avian community can be divided into two parts, after referring to the work done by Wang et al (2004), we defined ''human-accompanying species'' as the birds which would not fly away while people walk close gently within less than 5 m, they are Eurasian tree sparrow *Passer montanus*, Light-vented Bulbul *Pycnonotus sinensis*, Spotted Dove *Streptopelia chinensis*, Eurasian Blackbird *Turdus merula*. The number of these four species comprises about 70% of the total bird count. The other part is considered as ''natural-accompanying species'' which include mostly rare and migrant birds; this group is easy to fly away when approached by humans.

Based on the bird count data, we developed the following table (Tab. 3) to show the bird indices in eight survey areas.

The results of the Tab. 3 indicate that bird density appeared very high in CFP but comparatively even in other places; bird diversity in the different research sites has a little variation. It concludes that the parks kept a consistent diversity of birds although the bird species and bird number could make a certain variation.

Tab. 2 Avian species observed at eight study sites in Shanghai downtown

Species	Number	Staging status	Relationship to human
Light-vented Bulbul (*Pycnonotus sinensis*)	496	R	HAS
Eurasian Tree Sparrow (*Passer montanus*)	691	R	HAS
Vinous-throated Parrotbill (*Paradoxornis webbianus*)	105	R	NAS
Yellow-billed Grosbeak (*Eophona migratoria*)	115	R	NAS
Eurasian Skylark (*Alauda arvensis*)	13	R	NAS
Great Tit (*Parus major*)	22	R	NAS
Grey-capped Greenfinch (*Carduelis sinica*)	13	R	NAS
Red-billed Leiothrix (*Leiothrix lutea*)	2	R	NAS
Daurian Redstart (*Phoenicurus auroreus*)	5	R	NAS
Orange-flanked Bush-Robin (*Tarsiger cyanurus*)	3	W	NAS
Barn Swallow (*Hirundo rustica*)	1	R	NAS
Long-tailed Shrike (*Lanius schach*)	38	R	NAS
Chinese Grey Shrike (*Lanius sphenocercus*)	1	W	NAS
Spotted Dove (*Streptopelia chinensis*)	115	R	HAS
Oriental Turtle Dove (*Streptopelia orientalis*)	8	R	NAS
White Wagtail (*Motacilla alba*)	18	R	NAS
Grey Wagtail (*Motacilla cinerea*)	1	R	NAS
Yellow Wagtail (*Motacilla flava*)	1	M	NAS
Crested Myna (*Acridotheres cristatellus*)	13	R	NAS
Eurasian Blackbird (*Turdus merula*)	151	R	HAS
Dusky Thrush (*Turdus naumanni*)	4	M	NAS
Grey-backed Thrush (*Turdus hortulorum*)	11	W	NAS
Scaly Thrush (*Zoothera dauma*)	3	W	NAS
Pale Thrush (*Turdus pallidus*)	10	M	NAS
Blue Whistling Thrush (*Myophonus caeruleus*)	1	W	NAS
Blue Rock-Thrush (*Monticola solitarius*)	1	R	NAS
Siberian Thrush (*Zoothera sibirica*)	5	M	NAS
Oriental Magpie-Robin (*Copsychus saularis*)	1	R	NAS
Yellow-browed Warbler (*Phylloscopus inornatus*)	14	M	NAS
Yellow-rumped Warbler (*Phylloscopus proregulus*)	1	M	NAS
Japanese Bush-Warbler (*Cettia diphone*)	32	W	NAS
Japanese White-eye (*Zosterops japonicus*)	4	R	NAS
Manchurian Bush Warbler (*Cettia canturians*)	1	R	NAS
Brown Bush-Warbler (*Bradypterus luteoventris*)	1	R	NAS
Streaked Reed-Warbler (*Acrocephalus sorghophilus*)	1	M	NAS
Orienfnl Tree Pipit (*Anthus hodgsoni*)	11	W	NAS
A specie of Scolopacidae	1	M	NAS
Black-billed Magpie (*Pica pica*)	8	R	NAS
Azure-winged Magpie (*Cyanopica cyana*)	26	R	NAS
Japanese Waxwing (*Bombycilla japonica*)	36	W	NAS
Bohemian Waxwing (*Bombycilla garrulus*)	18	W	NAS
Little Grebe (*Tachybapus ruficollis*)	8	R	NAS
Mallard (*Anas platyrhynchos*)	7	W	NAS
Common Pochard (*Aythya ferina*)	1	W	NAS
Falcated Duck (*Anas falcata*)	1	W	NAS
Pintail (*Anas acuta*)	1	W	NAS
Spot-billed Duck (*Anas poecilorhyncha*)	4	W	NAS
Common Moorhen (*Gallinula chloropus*)	1	R	NAS
Common Kingfisher (*Alcedo atthis*)	2	R	NAS
Eurasian Hoopoe (*Upupa epops*)	1	R	NAS
Hwamei (*Garrulax canorus*)	13	R	NAS
Black-crowned Night-Heron (*Nycticorax nycticorax*)	14	W	NAS
A specie of Phasianidae	1	R	NAS
White-cheeked Starling (*Sturnus cineraceus*)	1	W	NAS
Grey Nightjar (*Caprimulgus indicus*)	2	R	NAS

R: Resident species; M: Migrant species; W: Winter species (Mackinnon et al, 2000).
HAS: Human-accompanying species; NAS: Nature-accompanying species.

2.2 Environmental factors

The ten environmental factors of the eight survey areas are listed (Tab. 4).

The data in the Tab. 4 showed that each group of

Tab. 3 Characteristics of avian community in Shanghai woodlots

Sample site	Avian community indices			
	Bird species (species)	Bird number (ind.)	Bird density (ind./ha)	Shannon & Weiner index
CFP	16	361	9.91758	0.65451
LHP	14	226	0.65639	0.65639
RMP	12	157	0.72097	0.72097
DNP	25	382	0.65731	0.65731
ZSP	9	290	0.67505	0.67505
YZG	10	146	0.70041	0.70041
CP	32	450	0.78952	0.78952
PB99	13	101	0.75135	0.75135
Mean ± *SD*	15.5 ± 8.0	264.1 ± 126.5	1.9 ± 3.3	0.7 ± 0.05

CFP, LHP, RMP, DNP, ZSP, YZG, CP, PB99 refer to Fig. 1.

Tab. 4 Values of the environmental variables in Shanghai woodlots

Factors	Samples							
	CFP	LHP	RMP	DNP	ZSP	YZG	CP	PB99
PA (ha)	36.4	28.5	10.0	68.0	21.4	11.2	140.3	3.0
WP (%)	39.6	7.0	4.8	10.3	5.7	6.9	19.8	8.0
VS (species)	160	164	100	200	260	214	250	49
CC (%)	43.9	31.4	34.0	20.2	34.2	19.5	35.5	13.4
SC (%)	44.9	32.4	40.7	29.7	40.4	39.5	25.5	35.0
GC (%)	52.4	49.0	37.9	66.3	44.5	47.5	50.5	13.5
HN (range)	5	4	2	4	3	3	3	1
LC (range)	3	5	2	5	2	1	5	2
HQ (ind./ha·d)	227	170	368	8	222	450	9	1
PW (m)	3.5	4.0	3.0	5.0	3.0	2.5	6.0	1.0

PA, WP, VS, CC, SC, GC, HN, LC, HQ, PW present the same as Tab. 1.
CFP, LHP, RMP, DNP, ZSP, YZG, CP, PB99 refer to Fig. 1.

Tab. 5 Linear relationship between park area and each avian community index

		Park area
Bird species	Correlation coefficient (*R*)	0.948
	Value of company probability (Sig.)	0.024*
Bird number	Correlation coefficient (*R*)	0.851
	Value of company probability (Sig.)	0.007**

* $P < 0.05$, ** $P < 0.01$.

the environmental factors is different at a certain extent. So we could conclude that each study site has its own environmental characteristics about area, structure inside, vegetation situation etc., which would affect the avian community potentially.

2.3 Relationship between the birds and environmental factors

We performed Pearson correlation analysis to iden-

Tab. 6 Regression analysis of environmental factors and avian community indices

		WP	VS	CC	SC	GC	HN	LC	HQ
Bird species	Correlation coefficient (*R*)				0.781			0.777	
	Value of company probability (Sig.)				0.022*			0.023*	
Bird number	Correlation coefficient (*R*)					0.722			
	Value of company probability (Sig.)					0.043*			
Bird density	Correlation coefficient (*R*)		0.747			0.927	0.761		
	Value of company probability (Sig.)		0.004**			0.001**	0.028*		
Bird diversity	Correlation coefficient (*R*)								
	Value of company probability (Sig.)								

* $P < 0.05$, ** $P < 0.01$.

WP, VS, CC, SC, GC, HN, LC, HQ refer to Tab. 1.

tify correlations among the ten environmental variables, we found that PW displayed strong correlation with PA ($R = 0.883$, $P < 0.01$). We then tested the multiple regression of PW and PA to each avian community index, The linear relationships between PA and each avian community index are listed in Tab. 5; PA has a highly positive correlation ($P < 0.05$) with bird species and a strong positive correlation ($P < 0.01$) to bird number.

We found that PW had a strong negative correlation ($R = -0.954$, $P < 0.01$) to bird density. The linear relationship is shown in Fig. 2, which clearly shows that the parks with narrower paths hold more birds.

We then looked at the relationship between the characteristics of avian community and the other eight environmental factors. The results are listed in the Tab. 6, showing that VS and GC had a strong positive correlation ($P < 0.01$) with bird density; HN had highly positive correlation ($P < 0.05$) with bird density; GC had highly positive correlation ($P < 0.05$) with bird number; SC and LC had a highly positive correlation ($P < 0.05$) with bird species; WP, CC and HQ did not have any significant correlation with the urban bird community.

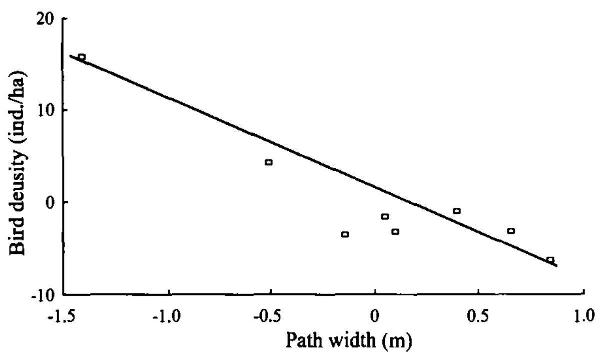

Fig. 2 Linear relationship between path width and bird density

3 Discussions and Conclusions

Our study indicated that park area, vegetation species, canopy cover, shrub cover, grass cover, gradient heterogeneity, location condition display significant positive correlation with avian community characteristics, and path width displays a negative correlation. The detailed analysis of the respective factors was listed as follows.

Park area: PA was the most important factor affecting bird species and numbers; larger parks hold more bird species and numbers than smaller ones. The result was consistent with other studies which showed that increasing woodland areas enhance birds numbers (Esteban, 2000; Stephanie et al, 2003; Yosihiro & Chobei, 1999). Nevertheless, we also found that PA had a little influence on bird density and diversity, so other variables must be having an influence on these factors (Chen et al, 2002b).

Path width: PW was the only factor displaying negative correlation with bird density. The parks with relatively narrow paths allowed the birds to move frequently and fly from one side to the other easily. Structural connectivity among the woodlands was important (Jamie et al, 2003).

Water percent: We found that WP has an insignificant effect on the avian community. Large water areas (used for amusement purposes) could be seen in most Shanghai parks. Most of the lakes had poor bird habitat—no islands and concrete surrounds.

Vegetation species: VS affected only bird density. Diverse vegetation can hold more bird species (Jukka, 1999). We found vegetation in Shanghai parks does not lead to an increase in bird diversity, because it was mainly ornamental (Yang et al, 2000). Ornamental vegetation had been planted and managed for scenic value and was not a good habitat for birds, especially the wary species.

Canopy cover: Tall trees could supply abundant food and hiding space. However, in our study, we showed that CC does not influence the avian community. A part of reasons probably was that the arbor composition kept a comparatively low diversity and *Cinnamoum camphora*, *Platanus orientalis* and *Magnolia grandiflora* are preponderant (Fu et al, 2000). An important objective should be to increase the tree biodiversity in order to enrich the avian biodiversity in the urban area.

Shrub cover: Shrub layer was relatively important in the vegetation construction; we found most of the natural-accompanying birds and rare species in the shrub layer, so shrub layer could affect the number of total bird species. Shrubs formed a good natural barrier between humans and birds, we believed enriching and protecting shrubs in urban can increase urban bird diversity, but a potentially serious problem was that the intensive gardening of this habitat may lead to excessive disturbance to birds.

Grass cover: GC affected bird numbers and density, but did not lead to an increase in bird species and diversity. This kind of habitat was not useful for wary bird species and rare species.

Hill number: The parks with some hilly areas created a more natural environment and human interference was relatively low. HN could increase bird density in the parks. However, we found that the vegetation in hilly areas was simple and sparse so that it did not lead to increase bird diversity.

Location condition: Location condition was commonly studied in urban parks (Jukka, 1999). In this study, we found that LC affects bird density. It was to be expected that main roads, residential and public buildings outside the parks, would significantly affect bird numbers.

Human quantity: As there were more than 5000 visitors in some parks each day, we were surprised that this did not lead to a reduction in bird numbers. In fact, the number of human-accompanying birds counted was preponderant in the parks, so people didn't seem to produce a large effect on their numbers.

Wildlife conservation especially for birds in urban habitats is increasingly important due to current urbanization trends (Morrison, 1986). Urban parks are important biodiversity hotspots in cities and urban parks of 10 – 35 ha contain most of the species recorded in cities (Esteban & Jukka, 2001). Tree-lined streets can increase urban landscape connectivity by providing alternative habitat for feeding and nesting of birds during the breeding season. Because urban woodlots are quite different from the natural forest, it is significantly important to set up a good relationship among the spatial structure, vegetation of the urban woodlot, avian species number and distribution.

Only a few species are adapted to life in cities (Jukka, 1999; Luan et al, 2003). We found that the numbers of human-accompanying birds in all the study sites is about 70% comprising only four species. This is an unsatisfactory situation.

The parks and green lands in Shanghai downtown have different styles and inner spatial structure. New design concepts include large-areas of water with stone banks, large lawn areas, garden beds needing lots of gardening and entertainment areas for people. Some of these developments may be helpful in increasing urban bird abundance and diversity, some may play a negative role. We hoped that our research and others would provide a case study for the government and park designers to protect this precious biological resource of urban areas. Our study indicated that park area, vegetation species, canopy cover, shrub cover, grass cover, gradient heterogeneity, location condition display significant positive correlation with avian community characteristics, and path width displays a negative correlation. The detailed analysis of the respective factors was listed as follows.

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References:

Almo F. 1997. Landscape structure and breeding bird distribution in a sub-Mediterranean agro-ecosystem [J]. *Landscape Ecology*, **12**: 365 – 378.

Andrew PA, Raymond JO. 2000. Hierarchical correlates of bird assemblage structure on northeastern USA Lakers [J]. *Environmental Monitoring and Assessment*, **62**: 15 – 37.

Blair RB. 1996. Land use and avian species diversity along an urban gradient [J]. *Ecological Applications*, **6**(2): 502 – 519.

Che SQ, Song YC. 2002. Analysis of landscape pattern of park system in city of Shanghai [J]. *Journal of Shanghai Jiaotong University (Agricultural Science)*, **20**(4):322 – 327. [车生泉，宋永昌. 2002. 上海城市公园绿地景观格局分析. 上海交通大学学报(农业科学版), **20**(4): 322 – 327.]

Chen SH, Ding P, Fan ZY, Zheng GM. 2002a. Selectivity of birds to urban woodlots[J]. *Zool. Res.*, **23**(1): 31 – 38. [陈水华，丁平，范忠勇，郑光美. 2002a. 城市鸟类对斑块状园林栖息地的选择性. 动物学研究, **23**(1): 31 – 38.]

Chen SH, Ding P, Zheng GM. 2002b. Research perspective on ecology of urban avian community [J]. *Acta Ecologica Sinica*, **22**(2): 165 – 169. [陈水华，丁平，郑光美. 2002b. 岛屿栖息地鸟类群落的丰富度及其影响因子. 生态学报, **22**(2): 165 – 169.]

Esteban FJ. 2000. Bird community composition patterns in urban parks of Madrid: The role of age, size and isolation [J]. *Ecological Research*, **15**: 373 – 383.

Esteban FJ. 2002. Can human disturbance promote nestedness: A case study with breeding birds in urban habitat fragments [J]. *Oecologia*, **131**: 269 – 278.

Esteban FJ, Jukka J. 2001. A habitat island approach to conserving birds in urban landscapes: Case studies from southern and northern Europe [J]. *Biodiversity and Conservation*, **10**: 2023 – 2043.

Fu HN, Yan LZ, Zhang LQ. 2000. Study on ecological structure of the ornamental plants community in Shanghai [J]. *Chinese Parks*, **16** (68): 22-25. [傅徽楠, 严玲璋, 张连全. 2000. 上海城市园林植物群落生态结构的研究. 中国园林, **16**(68): 22-25.]

Ge XD, Zhao YM. 1999. The effects of the urbanization on the temperature in creasing in Shanghai [J]. *Yunnan Geographic Environment Research*, **11**(1): 44-50. [葛向东, 赵咏梅. 1999. 城市化对上海的增温效应. 云南地理环境研究, **11**(1): 44-50.]

Huang ZY, Shun ZH, Yu K. 1993. [M]. Bird Resources and Habitat in Shanghai [M]. Shanghai: The Publishing House of Fu Dan University. [黄正一, 孙振华, 虞 快. 1993. 上海鸟类资源及其生境. 上海:复旦大学出版社.]

Jamie HM, George RH, Christopher EM, George RH, Kristen ES. Designing urban greenways to provide habitat for breeding birds [J]. *Landscape and Urban Planning*, [in press]

Jukka JA. 1999. Occurrence of breeding bird species in urban parks: Effects of park structure and broad-scale variables [J]. *Urban Ecosystems*, **3**: 21-34.

Luan XF, Liu JF, Hu ZJ, Xu HF, Xie YM, Du DC. 2003. Summer and winter avian community in Shanghai suburban area [J]. *Chinese Journal of Zoology*, **38**(3): 69-76. [栾晓峰, 刘俊峰, 胡忠军, 徐宏发, 谢一民, 杜德昌. 2003. 上海郊区冬夏季鸟类群落特征比较. 动物学杂志, **38**(3): 69-76.]

Lu WD. 2000. Statistical Analysis of SPSS for Windows [M]. Beijing: Publishing House of Electronics Industry. 186-198. [卢纹岱. 2000. SPSS for Windows 统计分析. 北京: 电子工业出版社. 186-198.]

Mackinnon J, Philipps K, He FQ. 2000. The Field Notebook of China Birds [M]. Changsha: Hunan Education Publishing House. [约翰. 马敬能, 卡伦. 菲利普斯, 何芬奇. 2000. 中国鸟类野外手册 [M]. 长沙:湖南教育出版社.]

Mark H, Holling CS. 2000. Detecting the scales at which birds respond to structure in urban landscapes [J]. *Urban Ecosystems*, **4**: 25-54.

Mark H, Kim KY. 2003. Land use, scale, and bird distributions in the Phoenix metropolitan area [J]. *Landscape and Urban Planning*, **62**: 55-68.

Morrison ML. 1986. Bird population as indicators of environmental change [J]. *Current Ornithology*, **3**: 429-451.

Nancy GT. 1987. Characteristics of urban woodlands affecting breeding birds diversity and abundance [J]. *Landscape and Urban Planning*, **14**: 481-495.

Raymond MS, Marybeth B, Denise AK, Christine MS. 1998. Patterns of human disturbance and response by small mammals and birds in chaparral near urban development [J]. *Urban Ecosystems*, **2**: 279-297.

Shanghai Agriculture and Forestry Administration. 2004. The Terraneous Wildlife Resources of Shanghai [M]. Shanghai: Shanghai Sciences and Technology Press. 183-197.

Stephanie M, Susan G, Kathy M. 2003. Urban bird diversity and landscape complexity: Species environment associations along a multiscale habitat gradient [J]. *Conservation Ecology*, **7**(1): 5. (online URL: http://www.consecol.org/vol7/iss1/art5.)

Tang SM, Tang LJ, Li HM. 2003. Effects of urbanization on avian community at Wujiaochang, Shanghai [J]. *Shanghai Environment Science*, **22**(6): 406-410. [唐仕敏, 唐礼俊, 李惠敏. 2003. 城市化对上海市五角场地区鸟类群落的影响. 上海环境科学, **22**(6): 406-410.]

Wang YP, Chen SH, Ding P. 2004. Flush distance: Bird tolerance to human intrusion in Hangzhou [J]. *Zool. Res.*, **25**(3): 214-220. [王彦平, 陈水华, 丁 平. 2004. 惊飞距离——杭州常见鸟类对人为侵扰的适应性. 动物学研究, **25**(3): 214-220.]

Yosihiro N, Chobei I. 1999. Prediction of species richness of breeding birds by landscape-level factors of urban woods in Osaka Prefecture, Japan [J]. *Biodiversity and Conservation*, **8**: 239-253.

Yang LL. 1995. Greenbelt Plan of Urban Park [M]. Beijing: Chinese Forestry Publishing House. [杨赉丽. 1995. 城市园林绿地规划 [M]. 北京:中国林业出版社.]

Yang XJ, Lin YX, Hu WH, Tang DQ. 2000. Investigation on species abundance of gardening plant community in Shanghai city [J]. *Chinese Park*, **16**(69): 67-69. [杨学军, 林源祥, 胡文辉, 唐东芹. 2000. 上海城市园林植物群落的物种丰富度调查. 中国园林, **16**(69): 67-69.]