Common blackbirds *Turdus merula* use anthropogenic structures as nesting sites in an urbanized landscape

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Abstract The common blackbird *Turdus merula* is one of the most highly urbanized bird species. However, to date, the use of anthropogenic structures as nesting sites in the common blackbird is rarely documented, and the factors influencing its use of the anthropogenic structures as nesting sites remain unclear. In this study, we systematically quantified and determined the factors influencing the use of anthropogenic structures as nesting sites in common blackbirds in a highly urbanized city of Hangzhou, China. We searched for nests of common blackbirds during four breeding seasons from 2010 to 2013. Among the 60 nests found, 34 nests were in anthropogenic structures such as wall ledges, air condition mounts, window canopies, cable poles, guardrails, eaves, balcony frames, flowerpots and flower shelves on balconies. We found that the available anthropogenic nest sites and the available nesting trees were main factors determining the use of anthropogenic structures as nesting sites in common blackbirds. In urban environments, the amount of available anthropogenic nesting sites increased significantly, whereas the number of natural nesting sites reduced greatly. Our results suggest that common blackbirds can adjust their nest sites in response to urbanization and such nesting behavior shifts may aid them to colonize urban environments. From a management viewpoint, our results indicate that behavioral flexibility should be taken into account for effective urban wildlife management and conservation.

Keywords Adaptation, Anthropogenic nest, Behavioral flexibility, Colonization, Urbanization

Urbanization is one of the most extreme forms of land-use alteration occurring at an accelerating rate worldwide (Marzluff et al., 2001; Gaston, 2010). Although urbanization often adversely affects and even causes extinction of native species (Soulé et al., 1988; McKinney, 2006; Husté and Boulinier, 2007; Sol et al., 2014), more and more bird species worldwide are colonizing and adapting to urban environments (Luniak, 2004; Möller, 2009; Franci and Chadwick, 2011). There is rapidly increasing interest in studying how species colonize urban habitats (Gaston, 2010; Lepczyk and Warren, 2012; Gil and Brumm, 2014). However, the factors limiting the colonization of cities by most bird species from rural areas remain poorly understood.

Urbanization often changes the resources upon which birds depend (Wang et al., 2009; Gaston, 2010; Ibañez-Alamo and Soler, 2010), including the type and availability of nesting sites (Beissinger and Osborne, 1982; Wang et al., 2008). Compared with rural sites, urban environments are characterized by increased abundance and type of anthropogenic nesting sites, whereas the number of natural nesting sites can be greatly reduced (Lancaster and Rees, 1979; Wang et al., 2008). Moreover, several prominent ecological characteristics that are specific only to urban ecosystems, such as the permanent presence of humans, noise pollution and traffic disturbance, have the potential to affect avian nest placement (Knight and Fitzner, 1985; Antczak et al., 2005; Wang et al., 2008; Yamac and Kirazli, 2012). To colonize and breed successfully in urban environments, individuals have to cope with these urban specific stresses.

The common blackbird *Turdus merula* was once a reclusive and timid forest species (Luniak et al., 1990), but now is one of the most common birds in the urban environment (Evans et al., 2010, 2012). To successfully colonize cities, urban blackbirds have made many behavioral and ecological adjustments, such as an ex-
tended breeding season, reduced propensity to migrate, singing higher-pitched songs, and being tamer than their rural conspecifics (Lunink et al., 1990; Gliwicz et al., 1994; Partecke et al., 2006; Partecke and Gwinner, 2007; Nemeth and Brumm, 2009; Evans et al., 2012). The adjustment in nesting behaviors such as nesting site shifts from natural trees to anthropogenic structures may reflect the ability of birds to adapt to urban ecosystems and have been documented in a wide range of bird species (Diamond, 1986; Luniak, 2004; Wang et al., 2008). However, to date, the use of anthropogenic structures as nesting sites in the common blackbird in urban environments is only reported occasionally in Europe (Partecke et al., 2006; Möller, 2010), and the factors influencing its use of anthropogenic structures as nesting sites remain unclear.

In this study, we undertook a systematic study to quantify the use of anthropogenic structures as nesting sites in common blackbirds by surveying their nests in a highly urbanized landscape of Hangzhou, China. We further examined the factors influencing their use of the anthropogenic structures as nesting sites. Understanding such adjustments in nesting behaviors and the underlying mechanism has important implications for the conservation and management of wildlife in urban ecosystems.

1 Materials and Methods

1.1 Study area

Hangzhou (118° 21′–120° 30′ E, 29°11′–30° 33′ N), the capital city of Zhejiang province, lies in the eastern coastal zone of China. With a population of 8.7 million and covering an area of 16,596 km², Hangzhou is one of the most developed cities in China. The city is covered with hills, plains, and water systems (e.g. rivers, lakes and ponds) (Wang et al., 2008). The climate is typical of the subtropical monsoon zone with hot summers and cold winters. The average annual temperature is 16.1°C, with the daily extremes ranging from –9.6°C in winter to 39.9°C in summer. Annual rainfall in the region is 1,435 mm (Wang et al., 2008, 2009).

All the habitats in the study region, based on their differences in building indexes, human disturbance and vegetation categories, can be classified into six main types: (1) building areas, (2) strips of street trees, (3) urban parks, (4) riparian areas, (5) farmlands, and (6) mountains (Wang et al., 2008). The building areas are located in the city center, including residential, commercial and industrial areas. These areas are featured by high human disturbance. The arboreal vegetation is often limited to small exotic trees. Lawns, gardens, native and ornamental flora are frequently found around the buildings (Wang et al., 2008). Strips of street trees often differ in their length, vegetation structure and human disturbance. The main human disturbance is from pedestrians and cars. Strips of street trees are comprised of a mix of deciduous and coniferous trees at least 3 m high. The trees line sidewalks about 5 m apart, and are mainly Cinnamomum camphora, Platanus hispanica, Populus spp., and Sophora japonica (Wang et al., 2003). Hangzhou has an extensive network of urban parks. The parks vary greatly in overall size (0.5 to 92.0 ha) and the amount of natural area (3.6% to 87.9%). The parks contain diverse habitats, including low shrubs, watered grass, deciduous and coniferous trees, community gardens and paved areas. The main human disturbance is the visitation by tourists and recreationists (Wang et al., 2013). The riparian areas are situated in western Hangzhou, and connect into networks. The vegetation of riparian areas is dominated by Diospyros kaki and Phyllostachys heterocycla about 3 m high. The main human disturbance is the activities of fishermen (Wang et al., 2008). The farmlands extend northeast and northwest of Hangzhou and the main crop types are rice and vegetables. A few deciduous trees and bamboos about 3 m high sprinkle the agricultural landscape. Activities by the farmers are the main disturbance (Wang et al., 2008). The mountains consist of a mix of deciduous and coniferous forests. The deciduous forests are dominated by Celtis tetandra, Liquidambar formosana, Platycarya strobilacea, Pterocarya stenoptera, Quercus acutissima, Q. fabri, Sassafras tzumu, Ulmus parvifolia, and Zelkova schneideriana. The evergreen forests are dominated by Castanopsis carlesii, C. sclerophylla, C. tibetana, Cinnamomum camphora, Cyclobalanopsis glauca, Lithocarpus glaber, and Phoebe sheareri. Shrub compose the substrates in most mountain areas. Mountain climbers are the main human disturbance (Wang et al., 2008).

1.2 Nest surveys

We actively searched for nests of common blackbirds during four breeding seasons (March – June) from 2010 to 2013. We randomly selected 10 sites from each habitat type to be representative of the landscape. At each of these 60 sites, we surveyed bird nests thoroughly each time per month along a transect line that was 600-m long and 50-m wide in each breeding season (Wang et al., 2008, 2009). Surveys were conducted usually between 08:00 and 16:00 hours, except when the weather was unfavorable such as heavy rain, high wind or high
temperatures (Robbins, 1981). During the survey, we walked the transects within the habitats and checked all the potential nest sites thoroughly, including trees, shrubs and anthropogenic objects (e.g. wall ledges, air condition mounts, window canopies, cable poles, guardrails, eaves, balcony frames, flowerpots and flower shelves on balconies). We checked the shrubs and low trees visually, and searched tall trees or high anthropogenic objects with an 8×42 binocular and a pole with a mirror (Parker, 1972; Wang et al., 2009). We also used indirect breeding behaviors of adults, such as nest building, distraction displays, incubation feeding, and nestling provisioning, to locate nests (Grégoire et al., 2003; Wang et al., 2008, 2009). Once found, we recorded the nest position with a GPS receiver. All the nests found were then categorized as either anthropogenic (nests on anthropogenic objects) or natural (nests on trees) for further analysis.

1.3 Habitat variables

We selected 10 habitat variables that may influence nest site use by common blackbirds (Table 1) (Osborne and Osborne, 1980; Wysocki et al., 2005). To quantify these variables, we set up a 50-meter radius circular plot around located nests. The plot size is appropriately the maximum size of the breeding territory of the common blackbird (Jackson, 1954; Wysocki et al., 2004). In each plot, we recorded the number and types of all trees and the potential anthropogenic nest sites (e.g. wall ledges, air condition mounts, window canopies, eaves, balcony frames, cable poles, guardrails, flowerpots and flower shelves on balconies), and then measured each for height. Shrubs were not considered as potential nest sites as no nest was found on shrubs in our study area.

Human disturbance, traffic load and noise pollution together for an hour each day per week in each plot, which standardized the variables and made them comparable. To determine human disturbance, we recorded the number of pedestrians passing by in 5-minute intervals from 09:00 to 10:00 hours in each plot in weekdays and weekends. We determined the traffic load by counting the number of vehicles crossing in both directions within 5-minute periods from 10:00 to 11:00 hours in each plot in weekdays and weekends (Fernández-Juricic and Telleria, 1999). Following a similar procedure, we measured noise pollution (dBA) with a HS5633A digital sound level meter in each plot (Wang et al., 2013). We repeated visiting the plots across weekdays and weekends. We also measured the area covered by lawns and pavements with a metric ruler within the plot, and then changed this to proportions. The area covered by lawns was used as an index of the availability of food resources (Fernández-Juricic and Telleria, 1999) because common blackbirds usually feed on the lawn (Chamberlain et al., 1999). The area covered by pavements was used as an opposite surrogate of the availability of nesting materials. Since common blackbirds need soil or mud to make their nests (Collar, 2005), the higher the proportion of area covered by pavements, the less nesting materials were available. Although common blackbirds sometimes can use plastic twine, plastic bags and wires as nesting materials (Kurucz et al., 2010), such artificial materials were never found in blackbird nests in our study area.

1.4 Statistical analyses

We employed logistic regression models and an information-theoretic approach to determine which combination of environmental variables best distinguished the anthropogenic nests from natural nests. The logistic regression models were built in four steps. First, we tested all variables for normality with Kolmogorov-Smirnov tests. We logarithmically or arcsine square-root transformed variables that were not normally distributed.

| Variables | Description |
|-----------|-------------|
| Available anthropogenic nest sites (n) | The number of all potential anthropogenic nest sites such as wall ledges, air condition mounts, window canopies, cable poles, eaves, balcony frames, guardrails, flowerpots and flower shelves on balconies |
| Available nesting trees (n) | The number and types of all trees that are higher than the minimum height of the nest tree (4.2 m) |
| No. of tree species (n) | No. of all species of trees |
| Tree height (m) | Height of the tree above the ground |
| Building height (m) | Height of the building above the ground |
| % Lawn | % Extent of lawn, an index of the availability of food resources |
| % Pavement | % Extent of pavement, an opposite surrogate of the availability of nesting materials |
| Noise (dBA) | Extent of noise pollution, measured with a HS5633A digital sound level meter |
| Traffic load (n) | The number of vehicles crossing by in 5-minute periods from 10:00 to 11:00 hours each day per week |
| Human disturbance (n) | The number of pedestrians passing by in 5-minute intervals from 09:00 to 10:00 hours each day per week |
However, several variables were still not normally distributed despite transformations (Table 2). Second, to screen variables for model building, we evaluated the data for correlations because strongly correlated variables ($r \geq 0.70$) likely measured the same or similar nest characteristics (Boal and Mannan, 1998; Soh et al., 2002). Since none of variables was highly correlated ($r < 0.70$) in our study (Table 3), we retained all the variables for further analyses. Moreover, to minimize the chances of overfitting data with a small sample size ($n = 60$) (Burnham and Anderson, 2002), we reduced the dataset by using $t$-tests (for normally distributed variables) and Mann-Whitney $U$ tests (for non-normally distributed variables) to compare features between anthropogenic nests and natural nests. We only retained five variables that differed ($P < 0.10$) between anthropogenic nests and natural nests (Table 2) (Boal and Mannan, 1998; Sergio et al., 2004). Finally, after the five variables were selected (Table 2), all possible models were fit using logistic regressions. Models were ranked using corrected Akaike’s information criterion (AIC$_c$) and Akaike weights ($\omega$) (Burnham and Anderson, 2002). As none of the models was clearly the K-L best ($\omega \geq 0.9$) (Table 4), a model averaging technique was used to calculate variable weights ($\omega_v$) that are the probabilities that each variable should be in the best model given the data. The set of models to be averaged was determined by starting with the model having the highest weight and adding additional models in order of decreasing weight until $\omega \geq 0.9$. The selected set of models was then reweighted so that the Akaike weights of the models that included the variable of interest (Burnham and Anderson, 2002). No interactions between variables were examined due to limited sample size. Values are given as mean ± SE and tests are two-tailed. All analyses were conducted with R v. 2.13.1 (R Development Core Team, 2013).

2 Results

2.1 The use of anthropogenic structures as nesting sites in common blackbirds

We found a total of 60 nests of common blackbirds. Of these, 34 nests (56.7%) were found in anthropogenic structures such as wall ledges ($n = 11$), flowerpots ($n = 8$), air condition mounts ($n = 7$), window canopies ($n = 4$), guardrails ($n = 2$), a cable pole ($n = 1$), and a flower shelf ($n = 1$) on a balcony (Fig. 1). The other 26 natural nests were built in native trees such as camphors *Cinnamomum camphora* ($n = 8$), Chinese firs *Cunninghamia lanceolata* ($n = 3$), Japanese blueberry trees *Elaeocarpus decipiens* ($n = 2$),weeping willow *Salix babylonica* ($n = 1$), China wingnuts *Pierocarya stenoptera* ($n = 2$), empress (*Paulownia sp.*) ($n = 1$), and persimmon *Diospyros kaki* ($n = 1$); and exotic trees such as cedar *Cedrus deodara* ($n = 3$), London planes *Platanus hispanica* ($n = 2$), southern magnolia *Magnolia tomentosa* ($n = 1$), and myrobalan plum *Prunus cerasifera* ($n = 1$).

2.2 Factors influencing the use of anthropogenic structures as nesting sites

Anthropogenic nests were significantly different from natural nests for five habitat variables (Table 2). Compared with natural nests, there were significantly more available anthropogenic nest sites, higher buildings and compared with natural nests, there were significantly more available anthropogenic nest sites, higher buildings and a large amount of pavements around anthropogenic nests. In contrast, the available nesting trees and the amount of lawns around anthropogenic nests were significantly higher than those of the natural nests (Table 2).

Table 2 The comparisons of habitat variables measured at 34 anthropogenic nests and 26 natural nests of common blackbirds in Hangzhou, China

| Variables                              | Anthropogenic nests | Natural nests | $t$-value | Z-value | $P$   |
|----------------------------------------|---------------------|--------------|-----------|---------|-------|
| Available anthropogenic nest sites     | 161.74 ± 15.62      | 52.31 ± 13.62| 5.094     | -5.624  | < 0.001|
| Available nesting trees                | 5.47 ± 1.17         | 37.38 ± 4.97 | -1.756    | 0.126   |
| No. of tree species                    | 4.68 ± 0.33         | 5.50 ± 0.32  | -1.553    | 0.184   |
| Tree height                            | 9.62 ± 0.38         | 10.58 ± 0.50 | -1.553    | 0.126   |
| Building height                        | 20.64 ± 1.13        | 13.64 ± 2.97 | -3.011    | 0.003   |
| % Lawn                                 | 0.10 ± 0.01         | 0.15 ± 0.02  | -1.882    | 0.059   |
| % Pavement                             | 0.60 ± 0.01         | 0.36 ± 0.04  | -4.434    | < 0.001 |
| Noise                                  | 52.32 ± 1.39        | 51.81 ± 0.60 | 0.045     | 0.964   |
| Traffic load                           | 7.96 ± 3.21         | 3.26 ± 0.46  | -0.053    | 0.958   |
| Human disturbance                      | 16.69 ± 1.64        | 16.36 ± 2.55 | 0.113     | 0.911   |

Univariate differences between the two samples were tested by means of $t$-tests or Mann-Whitney $U$ tests.
The pictures clockwise from top left are flowerpots, wall ledge, air condition mount, window canopies, balcony frame, and eaves. Photos are provided by Qin Huang and Yonghua Chen.

For the logistic models including the five habitat variables that differed significantly between anthropogenic nests and natural nests (Table 2), eight models were required to reach a cumulative Akaike weight of 0.90 (Table 4). The two best predictors for the use of anthropogenic structures as nesting sites in common blackbirds were the available anthropogenic nest sites ($\omega_1 = 1$) and available nesting trees ($\omega_1 = 1$) (Table 4). These two variables were included in the top eight models. The next best predictor was a positive association with building height ($\omega_3 = 0.62$) (Table 4). In contrast, there were little support for the amount of lawns ($\omega_1 = 0.21$) and pavements ($\omega_1 = 0.40$) as predictors for the use of anthropogenic structures as nesting sites in common blackbirds (Table 4).

3 Discussion

3.1 Factors influencing the use of anthropogenic structures as nesting sites

The common blackbird is considered to be one of the most highly urbanized bird species (Luniak et al., 1990). However, to date, the use of anthropogenic structures as nesting sites in common blackbirds is only documented occasionally in Europe (Partecke et al., 2006; Møller, 2010). In China, one nest on a balcony was observed in Pingtan County in Fujian province (Cai, 2001), and two nests in flowerpots were discovered in Ji’an of Jiangxi province (Huang et al., 2011). Here we recorded 34 nests in eight kinds of anthropogenic structures in Hangzhou, which is the largest number recorded in China, probably due to the high degree of urbanization of Hangzhou city. To our knowledge, only our study and Møller (2010) have systematically quantified and determined the factors influencing the use of anthropogenic structures as nesting sites in common blackbirds, which thus fills in a significant gap.

| Available anthropogenic nest sites | Available nesting trees | No. of tree species | Tree height | Building height | % Pavement | % Lawn | Noise | Traffic load | Human disturbance |
|-----------------------------------|------------------------|---------------------|-------------|----------------|------------|-------|------|--------------|------------------|
| -0.512***                         | -0.198                 | -0.196              | 0.574***    | 0.640***       | -0.362**   | 0.114 | -0.137| 0.015       |
| Available nesting trees           | 0.249                  | 0.303*              | -0.414**    | -0.604***      | 0.360**    | 0.029 | 0.093| 0.100       |
| No. of tree species               | 0.019                  | -0.164              | -0.282*     | 0.044          | 0.044      | -0.139| -0.139| -0.153      |
| Tree height                       | -0.230                 | -0.164              | -0.064      | -0.030         | 0.068      | 0.019 |      |             |
| Building height                   | 0.638***               | -0.397**            | 0.291*      | -0.075         | 0.099      |      |      |             |
| % Pavement                        |                        |                     |             |                |            |      |      |             |
| % Lawn                            |                        |                     |             |                |            |      |      |             |
| Noise                             |                        |                     |             |                |            |      |      |             |
| Traffic load                      |                        |                     |             |                |            |      |      |             |
| Human disturbance                 |                        |                     |             |                |            |      |      |             |

* $P<0.05$; ** $P<0.01$; *** $P<0.001$. 

Table 3 The correlation matrix of 10 habitat variables measured at 60 blackbird nests in Hangzhou, China
Building height also appears to influence the use of anthropogenic structures as nesting sites in common blackbirds. Building height may influence the use of anthropogenic structures as nesting sites in at least two ways. First, building height may influence blackbird nest placement by affecting the amount of available anthropogenic nesting sites. Our results indicate that the higher the building, the more anthropogenic nesting sites. Our results indicate that the higher the building, the more anthropogenic nesting sites were available as these two variables were positively and significantly correlated (Table 3). Second, building height may also influence blackbird nest placement through its link to nest height. Ludvigi et al. (1995) found that high nest height can increase fitness benefits such as breeding success in common blackbirds.

Although the amount of lawns and pavements differed significantly between anthropogenic nests and natural nests, these two variables were not correlated with the use of anthropogenic structures as nesting sites in common blackbirds. Two main factors may explain why these correlations were weak. First, the amount of lawns and pavements were significantly related to and probably were covariables of the available anthropogenic nest sites and available nesting trees (Table 3), which are main factors determining the use of anthropogenic structures as nesting sites in common blackbirds. Second, we used the amount of lawns and pavements as indices of the availability of food resources and nesting materials. However, these two variables only gauge the availability of food resources and nesting materials indirectly and roughly (Fernández-Juricic and Tellería, 1999). Probably they can not represent the availability of food resources such as earthworms and caterpillars (Chamberlain et al., 1999) and nesting materials (e.g. soil and mud) (Collar, 2005) precisely.

Several urban-specific characteristics, such as the permanent presence of humans, noise pollution and traffic disturbance, are often hypothesized to affect avian nest placement (Knight and Fitzner, 1985; Antczak et al., 2005; Wang et al., 2008; Yamac and Kirazli, 2012). However, our results are not consistent with these hypotheses. Human disturbance, noise pollution and traffic dis-
turbance had little effects on blackbird nest placement because they did not differ between anthropogenic nests and natural nests (Table 2). These variables thus were not included in the further logistic regression models.

Nest predation is suggested to affect avian nest placement (Martin, 1993; Grégoire et al., 2003). The nest predators of blackbirds in urban environments include black-billed magpies *Pica pica*, domestic cats *Felis domesticus* and red squirrels *Sciurus vulgaris* (Groom, 1993; Fernández-Juricic and Tellería, 1999; Grégoire et al., 2003). The available anthropogenic nest sites and available nesting trees explained a huge amount of variation (90.0%) in blackbird nest placement. Nest predation could perhaps explain some of the remaining variation. However, as we currently have no data on the abundance and distribution of nest predators, its role in determining blackbird nest placement warrants further study.

Habitat complexity is also suggested to influence avian nest site selection. Hatchwell et al. (1996) found the index of habitat complexity (cover score) was a pivotal variable influencing the choice of nesting sites by common blackbirds. The effects of habitat complexity on the differential occupation of anthropogenic/natural structures as nesting sites by common blackbirds cannot be excluded from the present study. It could probably account for some of the remaining variation in blackbird nest placement.

Several studies have suggested that exotic plants can affect avian populations by altering brood parasitism rates, daily mortality rates, nest predation and nesting success (Schmidt and Whelan, 1999; Reichard et al., 2001; Remes, 2003; Borgmann and Rodewald, 2004). In our study, eight nests of common blackbirds were found in exotic trees such as cedar *Cedrus deodara*, London plane *Platanus hispanica*, southern magnolia *Magnolia tomentosa*, and myrobalan plum *Prunus cerasifera*. To what extent these exotic plants would influence common blackbirds is largely unknown due to the lack of related data. The placement of nests in these exotic trees is probably a novel adaptation to urbanization.

The shift in nesting sites from natural places to anthropogenic structures in urban environments may reflect the ability of birds to adapt to urban ecosystems (Luniak, 2004). Such adjustments in nesting behaviors have been reported repeatedly in many other bird species such as metallic starlings *Aplonis metallica*, house sparrows *Passer domesticus*, Eurasian wrens *Troglodytes troglodytes*, spotted flycatchers *Muscicapa striata*, great tits *Parus major*, common chaffinch *Fringilla coelebs*, common swifts *Apus apus*, common house-martins *Delichon urbica*, and black-billed magpies *Pica pica* (Diamond, 1986; Wang et al., 2008; Möller, 2010). The shift in nesting sites from natural places to anthropogenic structures may have important consequences for the persistence of the species in urban environments (Wang et al., 2008; Möller, 2010). However, the adaptive fitness of these adjustments in nesting behaviors in common blackbirds, such as nesting success, hatching rate or nestling fates, was not assessed in this study. Therefore, future work should examine the adaptive fitness of these adjustments in nesting behaviors.

### 3.2 Management implications

In the context of global and accelerating urbanization, an understanding of the adjustments in nesting behaviors in birds and the underlying mechanisms has important implications for the management and conservation of wildlife in urban ecosystems. Our results suggest that common blackbirds can shift their nesting sites from natural trees to many kinds of anthropogenic structures in response to urbanization. Like the common blackbird, more and more wildlife worldwide are adapting to urban environments (Luniak, 2004), and such adaptation often occurs with obvious shifts in behavioral characteristics (Ditchkoff et al., 2006; Partan et al., 2010; Sol et al., 2013). However, previous management efforts for urban wildlife often rely heavily on populations of rural wildlife, whereas these behavioral differences are rarely considered (Ditchkoff et al., 2006; Wang et al., 2009; Sol et al., 2013). Thus, future management efforts should take behavioral flexibility into account for effective urban wildlife management and conservation.

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WANG YP et al.: Nest-site adjustment by urban blackbirds

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