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Author(s): Ivana P. Romero, Mariano Codesido and David N. Bilenca
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NEST BUILDING BY MONK PARAKEETS *MYIOPSITTA MONACHUS* IN URBAN PARKS IN BUENOS AIRES, ARGENTINA: ARE TREE SPECIES USED RANDOMLY?

CONSTRUCCIÓN DE NIDOS POR LA COTORRA ARGENTINA *MYIOPSITTA MONACHUS* EN PARQUES URBANOS DE BUENOS AIRES, ARGENTINA: ¿SON USADAS AL AZAR LAS ESPECIES ARBÓREAS?

Ivana P. Romero[1] *, Mariano Codesido[1] and David N. Bilenca[1]

Summary.—The monk parakeet *Myiopsitta monachus* is a very successful invasive species and a worldwide agricultural pest. Knowledge of its nest tree selection could be a valuable pest control tool, given that its population expansion could be more effectively controlled by reducing potential nest tree availability. In this study we describe monk parakeet use and selection patterns of nest trees in five parks in Buenos Aires, Argentina. The species and structural characteristics of each nest tree was recorded. A census of potential nest trees was also performed to calculate Savage's selectivity index for each tree species. We found 128 parakeet nests in 60 trees. The tree species selected by monk parakeets were cedars *Cedrus atlantica*, araucaria pines *Araucaria* sp. and palms (*Butia capitata*, *Washingtonia robusta*, *Syagrus romanzoffiana*, *Phoenix* sp.). Cedars were particularly selected as nest trees: they supported 40% of all nests and held more nests per tree than any other species. This is the first study to reveal that cedars and araucarias are selected by monk parakeets. Nest tree selection is a context-dependent process and it is guided by tree species and their structural characteristics and phenology. According to our findings, it would be advantageous to implement a careful selection of the tree species to be planted in Buenos Aires City parks and in urban areas elsewhere, in order to properly manage potential human-bird conflicts.

Key words: nesting tree, plagiotropic growth, Psittacidae, selection.

Resumen.—La cotorra argentina *Myiopsitta monachus* es una especie invasora muy exitosa y una plaga agrícola en muchos de los países en que se encuentra establecida. El estudio de la selección de árboles nido podría ser una herramienta valiosa para controlar esta plaga de forma más eficiente. En este trabajo se describen los patrones de uso y selección de árboles nido de la cotorra común en cinco par-

[1] Grupo de Estudios sobre Biodiversidad en Agroecosistemas (GEBA), Departamento de Biodiversidad y Biología Experimental, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires and IEGEBA (UBA-CONICET), Argentina.

* Corresponding author: iv.romero@hotmail.com

ques de la Ciudad Autónoma de Buenos Aires (Argentina). Se registró cada árbol nido junto con su especie y características estructurales. Asimismo, se realizó un censo de árboles nido potenciales para calcular el índice de selectividad de Savage para cada especie arbórea. Se encontraron 128 nidos de cotorra en 60 árboles. Las especies seleccionadas por las cotorras para nidificar fueron cedro *Cedrus atlantica*, araucaria *Araucaria* sp. y palmeras (*Butia capitata*, *Washingtonia robusta*, *Syagrus romanzoffiana*, *Phoenix* sp.). Los cedros representaron un caso particular como árboles nido puesto que sostuvieron el 40% de los nidos registrados y albergaron la mayor cantidad de nidos por árbol. Este es el primer estudio que encuentra que los cedros y las araucarias son seleccionados por la cotorra común para nidificar. La selección de árboles nido es un proceso dependiente del contexto y está guiado por la especie arbórea y sus características estructurales y fenológicas. A partir de estos resultados, se sugiere implementar una selección cuidadosa de las especies a plantar en los parques de la Ciudad Autónoma de Buenos Aires y de parques en zonas urbanas donde habite la cotorra argentina en general, de tal modo que pueda realizarse un manejo adecuado ante potenciales conflictos entre los humanos y estas aves.

Palabras clave: árboles de nidificación, crecimiento plagiotrópico, Psittacidae, selección.

Introduction

Species use different resources in order to survive and reproduce. In the scientific literature, the words *use*, *selection* and *preference* have been applied widely and often interchangeably when information on patterns of resource exploitation is presented (Litvaitis *et al*., 1994). *Use* simply indicates an association when habitat resources are discussed. *Selection*, however, implies that an animal is choosing among alternative habitats that are available to it. Thus, use is selective if components are exploited disproportionally to their availability (Johnson, 1980). *Preference* is determined independently of availability; that is, an animal is allowed access to different resources on an equal basis. This information can be obtained only under unique conditions (*e.g*. enclosure experiments; cafeteria experiments). Because of the unique nature of preference experiments, we will focus our attention on developing an understanding of habitat selection.

In birds, many studies have focused on nest site selection, these being one of their most important resources, so that the behaviour involved in nest-site selection is considered to be adaptive (Collias and Collias, 1984). Among those attributes that determine nest site selection, the most studied include substratum (Martin and Roper, 1988; Wilson and Cooper, 1998; Segura and Arturi, 2009), protection from weather conditions and predators (Nilsson, 1984; Götmark *et al*., 1995; Rodríguez *et al*., 2006; Fisher and Wiebe, 2005) and proximity to food resources (Brown *et al*., 1992).

The monk parakeet *Myiopsitta monachus* is native to subtropical and temperate woodlands in South America (Collar, 1997). It underwent very significant range expansion in its native area during the 20th century, particularly in the Pampas of Argentina (Bucher and Aramburú, 2014), where it has become very abundant (Codesido *et al*., 2012). In addition, the monk parakeet is a very successful invasive species that has become established in urban and suburban areas on three continents through both unintentional and deliberate introductions (Burger and Gochfeld, 2000; Russello *et al*., 2008; Strubbe and Matthysen, 2009; MacGregor-Fors *et al*., 2011). It is unique among parrots in that it builds communal nests, independent of natural cavities (Navarro *et al*., 1992; Eberhard, 1998), a habit that may contribute to its success as an invasive species (Martínez *et al*., 2013). Monk parakeets have become an agricultural pest both within their original

and alien ranges (Conroy and Senar, 2009; Canavelli *et al*., 2014). Moreover, their arrival in urban areas has also provoked a series of problems, including damage to ornamental and native trees and shrubs (Kibbe and Cutright, 1973), interference with utility poles and other man-made structures (Burger and Gochfeld, 2009), noisiness and introduction of diseases and parasites (Conroy and Senar, 2009; Rodríguez-Pastor *et al*., 2012).

Knowledge of nest tree selection could be a valuable pest control tool, given that population expansion could be controlled more effectively by reducing the availability of potential nest trees (Bilenca *et al*., 2012; Codesido *et al*., 2015). This would also be a less aggressive alternative to the lethal chemical methods traditionally used (Volpe and Aramburú, 2011).

In Argentina, several studies have aimed to characterise monk parakeet nest trees. In both La Plata City and rural areas of Buenos Aires province, monk parakeets show a high affinity for tall *Eucalyptus* trees, which has been related to reduction of predation risk and human control (Volpe and Aramburú, 2011; Bucher and Aramburú, 2014; Codesido *et al*., 2015). Although the monk parakeet was originally associated mainly with fringing woodlands on the pampas (Gibson, 1919; Daguerre, 1936), it quickly adapted to artificial woodlands around rural facilities (Bucher and Aramburú, 2014).

Furthermore, in urban areas where monk parakeets were introduced, their nests have been observed upon cedars *Cedrus* sp. and palms *Phoenix* sp. in Spain (Martín Pajares, 2005; Sol *et al*., 1997) and on coconut palms *Cocos nucifera* in the United States (Burger and Gochfeld, 2000). However, most earlier studies have not considered the availability of tree species in those urban areas, so that there are no previous studies analysing whether the tree species used for nest building by monk parakeets are used randomly or actively selected.

Here we hypothesise that the trees used for nest building by monk parakeets are a non-random set of the trees available, and that the tree species selected for nest building are context-dependent *i.e*. of those tree species available in a particular urban park. The aim of this study is to describe' the use and selection of nest trees by monk parakeets in five parks of Buenos Aires City (Argentina), and to discuss which structural attributes of these tree species may be important for nest building by monk parakeets.

Material and methods

We conducted our study from December 2012 to June 2013 in five of the major parks of Buenos Aires City, Argentina (34° 36' 12'' S, 58° 22' 54''W) where monk parakeet nests were observed: Centenario (area: 12 ha), Lezama (8 ha), Patricios (10 ha), Saavedra (10 ha) and Chacabuco (20 ha; fig. 1). All these parks are of public access and are mostly used for recreational purposes; they represent ~10% of the city's parks area and were designed and created between 1874 and 1909 (Fernández Balboa, 2012).

We surveyed all parks in their entireity. Within each park we first performed a census of potential monk parakeet nest trees and recorded their diameter at breast height (DBH) ≥ 70 cm (Volpe and Aramburú, 2011), in order to further analyse the selection of different tree species. Palms were included in each census regardless of species and DBH, since palms are also potential nest trees for monk parakeets (Sol *et al*., 1997; Burger and Gochfeld, 2000).

We visually located all monk parakeet nests in each park. Each tree with at least one monk parakeet nest on it was recorded as a nest tree, after checking that the nest had at least one active entrance. We also recorded a series of nest tree characteristics including: tree species, DBH, height category (< 5 m,

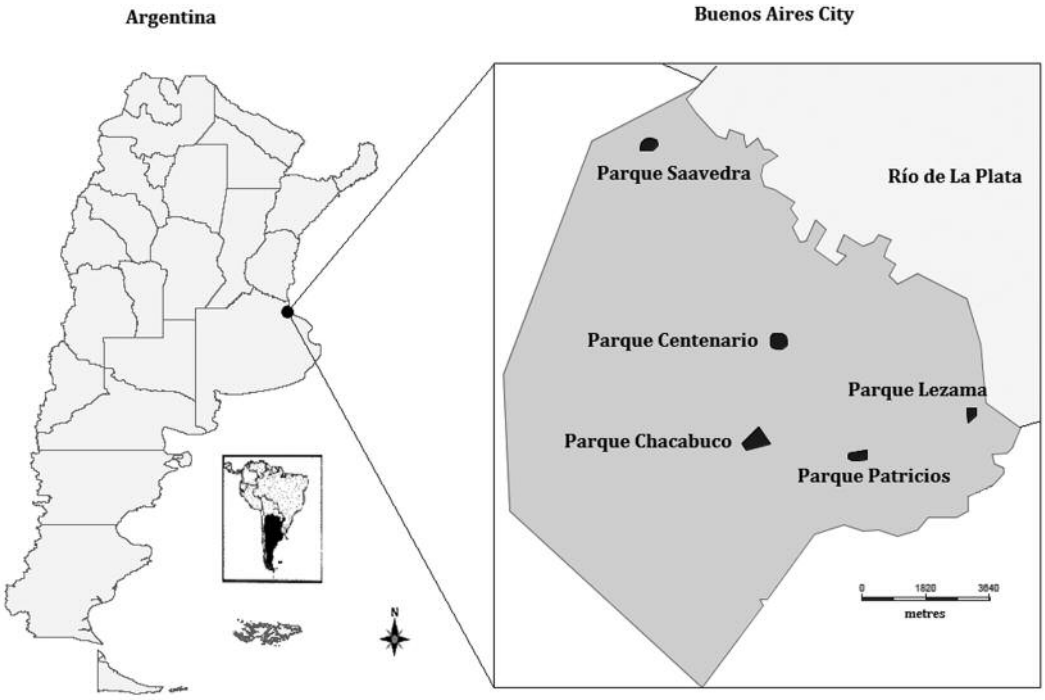

FIG. 1.—Location of the Buenos Aires City parks considered in the present study: Centenario, Chacabuco, Lezama, Patricios and Saavedra.
[Ubicación de los parques de la Ciudad de Buenos Aires considerados en el presente estudio: Centenario, Chacabuco, Lezama, Patricios y Saavedra.]

5.1-10 m, 10.1-15 m, 15.1-20 m, 20.1-25 m and > 25 m) and type of branch supporting the nest. The branch supporting the nest was categorised as primary if the nest was on the trunk or on a branch that emerged from it; secondary if the nest was on a branch that emerged from a primary branch, and so on (Volpe and Aramburú, 2011).

Finally, for each nest tree species at each park we calculated Savage's selectivity index (Atienza, 1994) according to the expression $W = U_i / D_i$, where U_i is the observed number of utilized units of resource *i* relative to the total of utilized resources, and D_i is the number of units of resource *i* available in the environment relative to the total resources available. Savage's index values range from 0 (complete avoidance) to infinite, being 1 the central value of no resource selection (Atienza, 1994). Levels of statistic significance were obtained after comparing a statistic based on W values with a χ^2 test of one degree of freedom (Manly *et al*., 1993).

RESULTS

We found 128 parakeet nests in 60 trees, an occupation rate of 3.4% of the total trees counted (table 1). The number of nests per park ranged from eight in Patricios park (n = 6 trees) to 46 in Saavedra park (n = 17 trees).

We recorded a total of 1,758 trees of which 1,569 were identified to species level

TABLE 1

Tree occupation by monk parakeet nests in Buenos Aires City parks, in order of decreasing occupation rate (Note: Total number of trees includes all trees ≥70cm of DBH except for palms, where all individuals were counted irrespective of their DBH).
[Árboles ocupados por nidos de cotorra común en parques de la Ciudad de Buenos Aires, ordenados según tasa de ocupación en forma decreciente. (Nota: el Número total de árboles corresponde a los árboles ≥70cm de diámetro a la altura del pecho DAP, excepto para las palmeras, las cuales fueron contadas en su totalidad, independientemente de su DAP)].

Nesting tree	Individuals with nest	Total number of trees	Occupation rate (%)
Cedar *Cedrus atlántica*	12	25	48.0
Palms *Butia capitata, Washingtonia robusta, Syagrus romanzoffiana and Phoenix* sp.	19	107	17.8
Elm *Ulmus procera*	3	19	15.8
Araucaria pines *Araucaria* spp.	11	70	15.7
Pine *Pinus* sp.	2	15	13.3
Casuarina *Casuarina cunninghamiana*	9	158	5.7
Eucalyptus *Eucalyptus* spp.	2	62	3.2
Plane tree *Platanus acerifolia*	1	231	0.4
Tipa *Tipuana tipu*	1	573	0.2
Individuals of nesting tree species	60	1266	—
Individuals of tree species without nest	—	492	—
Total trees	60	1758	3.4

(28 species), 101 to genus (6 genera) and 88 were not identified (see Supplementary Electronic Material for a complete list of tree species). The dominant species were tipas *Tipuana tipu*, plane trees *Platanus acerifolia* and casuarina *Casuarina cunninghamiana*, which represented 55% of counted trees (962 individuals).

The trees most frequently used by monk parakeets were cedars, palms (*Butia capi-*

TABLE 2

Characteristics of nest trees used by monk parakeets in Buenos Aires City parks, ordered by number of individuals with a nest. DBH = Diameter at breast height, expressed as mean ± SE (range); [p] = perennial; [d] = deciduous.

[Características de los árboles nido utilizados por la cotorra común en parques de la ciudad de Buenos Aires, ordenados según número de individuos con nido. DBH = diámetro a la altura del pecho, expresado como media ± ES (rango); [p] = perenne; [d] = deciduo.]

Nesting tree	Individuals with nest	DBH (cm)	Height (m)	Type of branch supporting the nest	Nests per tree
Palms [p] *Butia capitata, Phoenix* sp., *Washingtonia robusta and Syagrus romanzoffiana*	19	56 ± 7 (19-115)	< 5-20	1st	1
Cedar [p] *Cedrus atlantica*	12	67 ± 4 (48-97)	5-20	1st-2sd-3rd-4th	4.2 ± 1.2 (1-16)
Araucaria pine *Araucaria* spp. [p]	11	63 ± 6 (29-97)	5-20	1st-2sd	2.3 ± 0.4 (1-6)
Casuarina [p] *Casuarina cunninghamiana*	9	69 ± 5 (47-88)	10-20	1st-2sd	2.5 ± 0.9 (1-8)
Elm [d] *Ulmus procera*	3	75 ± 10 (57-90)	10-20	2sd	1
Pine [p] *Pinus* sp.	2	50 ± 1 (49-51)	10-25	1st-2sd	2 ± 1.4 (1-3)
Eucalyptus [p] *Eucalyptus* spp.	2	117 ± 2 (115-119)	15-20	2sd	1
Plane tree [d] *Platanus acerifolia*	1	65	10-15	1st	1
Tipa [p] *Tipuana tipu*	1	80	10-15	3rd	1

tata, *Washingtonia robusta*, *Syagrus romanzoffiana* and *Phoenix* sp.) and araucaria pines (*Araucaria* spp., at least three different species), with occupation rates per tree species ranging from 15% to 48% (table 1).

The 60 nest trees included 12 different species (table 2). Most nests (78%) were found on perennial species: araucaria pines, palms, pine trees *Pinus* sp., eucalyptus trees *Eucalyptus* spp. and cedars. The remaining

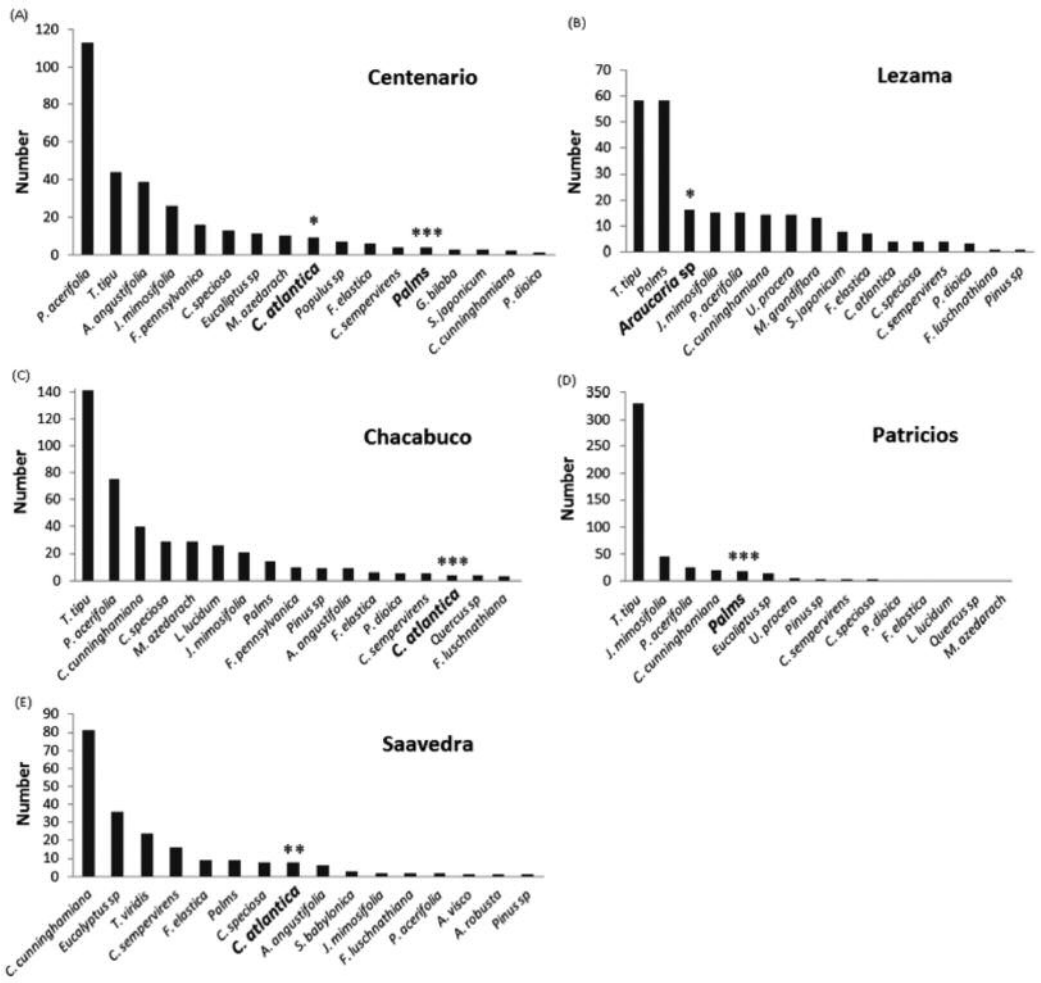

FIG. 2.—Number of trees of each species (in order of decreasing abundance) in the five parks studied (A) Centenario Park, (B) Lezama Park, (C) Chacabuco Park, (D) Patricios Park and (E) Saavedra Park. Nest tree species selected by monk parakeets are in bold (Savage's selectivity index): * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$ (χ^2 Test).

*[Número de árboles de cada especie, en orden decreciente, en los cinco parques estudiados (A) Parque Centenario, (B) Parque Lezama, (C) Parque Chacabuco, (D) Parque Patricios y (E) Parque Saavedra. Las especies de árboles seleccionadas para nidificar aparecen en negrita (índice de selectividad de Savage): * = P < 0,05, ** = P < 0,01, *** = P < 0,001 (Test χ^2).]*

five nests were found in deciduous trees: three elms *Ulmus procera*, one plane tree and one tipa.

The average DBH of all the nest trees was 60 ± 3 cm, n = 60, with a range of 19-119 cm (table 2). Eucalyptus trees showed the largest DBH (117 ± 2 cm, n = 2). The tallest nest trees were pines (10-25 m), whereas two palms with nests were within the lowest height category (< 5 m) (table 2). Most nests were placed on primary (38%) or secondary branches (46%) (table 2). Individual cedars supported the largest number of monk parakeet nests (4 ± 1, N = 12). In contrast, palms supported only one nest per tree (table 2).

Savage's selectivity index reveals that cedars were highly selected by monk parakeets in three of the four parks where they were available (Chacabuco: $\chi^2_1 = 178.6$, $P < 0.001$; Centenario: $\chi^2_1 = 5.6$, $P < 0.05$; Saavedra: $\chi^2_1 = 9.9$, $P < 0.01$) (fig. 2). Other tree species selected by monk parakeets for nesting were palms (Centenario: $\chi^2_1 = 122.5$, $P < 0.001$: Patricios: $\chi^2_1 = 87.0$, $P < 0.001$) and araucaria pines (Lezama: $\chi^2_1 = 5.1$, $P < 0.05$) (fig. 2).

Discussion

This study reveals that, in Buenos Aires City parks, monk parakeets use a non-random set of tree species to site their nests. The tree species selected included cedars, araucaria pines and palms. Most of these tree species have previously been reported as used for nesting by monk parakeets (Martín Pajares, 2005; Sol *et al*., 1997; Burger and Gochfeld, 2000). Moreover, palms have previously been described as the species selected as nest trees in urban parks where monk parakeets have been introduced (Sol *et al*., 1997). The present study reveals that cedars and araucarias are also selected by monk parakeets.

Our results are in agreement with previous studies suggesting that the monk parakeet selects nest trees according to particular attributes of the available tree species (Sol *et al*., 1997). In our study, all tree species selected as nest trees have perennial foliage and so may offer a better refuge and better protection against natural disturbances than trees with deciduous foliage. Permanent foliage, together with a particular tree structure, may determine nest tree selection by monk parakeets.

Cedars are strongly selected by monk parakeets. Cedars have a vertical growth habit with plagiotropic branches, emerging in specific and sequential areas along the trunk (Turnbull, 2005). Their compact foliage is set on conical branches (Barreiro, 2006), creating many sheltered spaces for monk parakeets to establish their large communal nests, and allowing cedars to support the largest number of nests per tree, on up to four different branch types. The significant selection of cedars as nest trees by monk parakeets accords with previous results by Martin Pajares (2005) from parks in Madrid (Spain), where over 65% of nests were found on cedars.

Araucaria pines also share some characteristics with cedars, such as plagiotropic branches and compact foliage. These are single-stemmed trees that shed their lower branches as they grow. Most nests on Araucarias were found on primary and secondary branches, very close to the trunk. These tree species provide a combination of height and branch disposition that could reduce predation risk and provide good shelter from adverse climatic conditions, as suggested for other selected tree species (Martin Pajares, 2005; Volpe and Aramburú, 2011).

Palms, which were also selected as nest trees, have a unique architecture compared to the other tree species. Their trunk grows without interruption and finishes in an umbrella-like crown. Sol *et al*. (1997) suggested that this structure could facilitate nest construction and maintenance. Some palms had the lowest height registered for nest trees

(< 5 m), in contrast with previous studies showing that monk parakeets use the tallest available trees to nest (Volpe and Aramburú, 2011; Codesido *et al*., 2015). However, even though some palms may be relatively short, they still are difficult to climb by terrestrial predators, such as cats (Sol *et al*., 1997).

It is noteworthy that *Eucalyptus* spp. was one of the less used nest tree species, even though previous studies have shown frequent use of this tree species by monk parakeets (Gibson, 1919; Volpe and Aramburú, 2011; Bucher and Aramburú, 2014). Volpe and Aramburú (2011) conducted a study of monk parakeet nest tree use in an urban area of Buenos Aires where eucalyptus was the only tree species considered in their surveys, given that monk parakeet nests were found exclusively on that tree species. A study conducted in rural landscapes by Codesido *et al*. (2015) also revealed a strong affinity of monk parakeets for planted eucalyptus trees. These contrasting results reveal that selection of nest trees is a context-dependent process, so that monk parakeets may not select eucalyptus trees where other tree species with more attractive traits are available. Therefore, it is possible that such species as cedars and araucaria pines offer a better combination of height, branch disposition and compact foliage that facilitates nest building and impedes access by terrestrial predators.

In addition to the structure and life history traits of tree species (perennial/deciduous), other factors such as the trees' spatial disposition, the specific location of trees within a certain park and the availability and proximity of food resources and other types of built substrates (i.e., man-made structures) may be influencing nest tree selection by monk parakeets in these parks (Sol *et al*., 1997; Minor *et al*., 2012). Many monk parakeets were seen feeding on leftovers from picnic zones or food stalls (I. Romero, pers. obs.), and some people may encourage bird presence by feeding them deliberately, as reported elsewhere (Minor *et al*., 2012). Moreover, monk parakeet nests in urban areas have been recorded on cell phone towers, utility poles and stadium lights (Burger and Gochfeld, 2009; Minor *et al*., 2012).

In conclusion, although monk parakeets are flexible with respect to the tree types and built substrates that they use for nesting, we have detected that this species uses a non-random set of tree species in urban parks, which is related to the architecture and presence/absence of foliage of specific trees. Thus, monk parakeet population densities in urban areas could be managed by limiting the number of potential nest trees available in public parks. These results are similarly relevant to those cities whose urban monk parakeet population may be a source population from which birds disperse to non-urban areas (Sol *et al*., 1997; Bucher and Aramburú, 2014).

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SUPPLEMENTARY ELECTRONIC MATERIAL

Additional supporting information may be found in the on-line version of this article. See volume 62(2) on www.ardeola.org.

Table S1: List of tree species present at Buenos Aires city parks.

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