Distribution patterns of invasive Monk parakeets (*Myiopsitta monachus*) in an urban habitat

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Abstract

*Distribution patterns of invasive Monk parakeets (*Myiopsitta monachus*) in an urban habitat.—* Several invasive species have been shown to have a marked preference for urban habitats. The study of the variables responsible for the distribution of these species within urban habitats should allow to predict which environmental variables are indicative of preferred habitat, and to design landscape characteristics that make these areas less conducive to these species. The Monk parakeet *Myiopsitta monachus* is an invasive species in many American and European countries, and cities are one of its most usual habitats in invaded areas. The aim of this paper was to identify the main factors that determine distribution of the Monk parakeet in Barcelona, one of the cities in the world with the highest parakeet density. We defined our model based on eight preselected variables using a generalized linear model (GLZ) and evaluated the strength of support for each model using the AIC–based multi–model inference approach. We used parakeet density as a dependent variable, and an analysis restricted to occupied neighbourhoods provided a model with two key variables to explain the distribution of the species. Monk parakeets were more abundant in neighbourhoods with a high density of trees and a high percentage of people over 65 years. This is interpreted by the fact that parakeets use trees as food sources and support for the nests, and that older people often feed the species. Data support the 'human–activity' hypothesis to explain how invasive species can successfully establish in a non–native habitat, and stress how limiting food resources, especially food supplied by humans, may be the easiest way to exert some control on Monk parakeet populations.

Key words: Biological invasions, Urban habitat, *Myiopsitta monachus,* Density of trees, The 'human–activity' hypothesis, Older people.

Resumen

*Patrones de distribución de la cotorra argentina (*Myiopsitta monachus*) en un hábitat urbano.—* Varias especies invasoras han demostrado tener una marcada preferencia por los hábitats urbanos. El estudio de las variables responsables de la distribución de estas especies dentro de hábitats urbanos debe permitir predecir cuáles son las variables ambientales indicativas de su hábitat preferido, y diseñar las características del paisaje que hacen a estas áreas ser menos favorables para estas especies. La cotorra argentina *Myiopsitta monachus* es una especie invasora en muchos países de América y de Europa, siendo las ciudades uno de los hábitats más comunes para esta especie en las áreas invadidas. El propósito de este estudio fue identificar los factores principales que determinan la distribución de la cotorra argentina en Barcelona, una de las ciudades en el mundo con una de las densidades más grande de cotorras. Hemos definido nuestro modelo basado en ocho variables preseleccionadas mediante un modelo lineal generalizado (GLZ) y evaluamos el poder de cada modelo a través de un análisis de inferencia multimodelo basado en el valor AIC. Utilizamos la densidad de cotorra argentina como variable dependiente y restringimos el análisis a aquellos barrios de la ciudad ocupados por la especie, obteniendo un modelo con dos variables clave que explicaban la distribución de la especie. Las cotorras argentinas eran más abundantes en aquellos barrios con alta densidad de árboles y con un alto porcentaje de personas mayores de 65 años. Esto se interpreta por el hecho de que las cotorras utilizan los árboles como fuente de alimento y como lugar de nidificación, y porque las personas mayores a

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menudo alimentan a la especie. Los datos apoyan la hipótesis de 'la actividad humana' para explicar cómo las especies invasoras pueden exitosamente establecerse en un hábitat no nativo, y subraya cómo la limitación de las fuentes de alimento, especialmente la comida suministrada por los seres humanos, puede ser la forma más sencilla de ejercer cierto control sobre las poblaciones de cotorra argentina.

Palabras clave: Invasiones biológicas, Hábitat urbano, *Myiopsitta monachus*, Densidad de árboles, Hipótesis de 'la actividad humana', Gente mayor.

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Introduction

The spread of exotic species is a major threat to native biodiversity and ecosystem functioning (Diamond, 1989; Temple, 1992; Wilcove et al., 1998; Kolar & Lodge, 2001; Stockwell et al., 2003). The main threats of invasive species can be summarized as: alteration of ecosystem processes (Raizada et al., 2008); decrease of native species abundance and richness through competition, predation, hybridization and indirect effects (Blackburn et al., 2004; Gaertner et al., 2009); changes in community structure (Hejda et al., 2009); and alteration of genetic diversity (Ellstrand & Schierenbeck, 2000). When invasive birds establish in a new habitat, they become part of the local biotic community, and this inevitably has an environmental and economic impact: transmission of avian diseases, or crop damages (Temple, 1992). Identifying the mechanisms that enable these species to establish viable populations in their new areas is one of the most important tools for their future management (Kolar & Lodge, 2001). Elucidating distribution patterns and the key variables that explain these patterns is an advisable approach (Franklin, 2009).

A number of hypotheses have been proposed to explain how invasive species can successfully establish in a non–native habitat. The 'climate–matching' hypothesis assumes that invasive species have a higher probability of successful establishment when they are introduced into regions with a climate similar to that in their native area (Williamson, 1996; Leprieur et al., 2008). In contrast with this, the 'human activity' hypothesis argues that it is human activity that favours this success by disturbing natural landscapes and increasing the number of individuals released and the frequency of introduction (Taylor & Irwin, 2004). These two hypothesis are the best supported by empirical data (Blackburn et al., 2009), and Temple (1992) showed that both mechanisms are conducive to successful reproduction. Some other hypothesis have additionally been proposed, as for instance the 'enemy–release' hypothesis, which states that the abundance or impact of some invasive species is related to the scarcity of natural enemies in the introduced range compared with the native range (Keane & Crawley, 2002; Torchin et al., 2002, 2003; Mitchell & Power, 2003).

The Monk parakeet is a common invasive bird species. Due to parrot trade, escapes from captivity, and the accidental or deliberate releases by people that had them as a pet, this species has spread its distribution range from South America (native habitat) to North America and Western Europe (Hyman & Pruett–Jones, 1995; Van Bael & Pruett–Jones, 1996; Cassey et al., 2004). This parakeet is characterized by building many nests within a communal nest structure of tightly inter–twined twigs and sticks (Spreyer & Bucher, 1998; Domènech & Senar, 2006; Burger & Gochfeld, 2009). Each individual nest is called a chamber and is used for breeding and roosting (Domènech & Senar, 2006). Nest structures are often clustered, forming colonies in a group of trees (Burger & Gochfeld, 2009). The nests are used throughout the whole year, and are repaired and reused year after year (Navarro et al., 1992; Eberhard, 1996, 1998).

This species is considered an agricultural pest in its native range (Bucher et al., 1990). In several of the invaded areas, the species has been able to establish increasingly large breeding populations (Bull, 1973; Shields, 1974; Summerour, 1990; Clavell et al., 1991; Schwab & Gwynn III, 1992; Caruso & Scelsi, 1994; Hyman & Pruett–Jones, 1995; Van Bael & Pruett–Jones, 1996). Through building its nests it causes considerable damage to ornamental trees and power lines, as well as to buildings and other structures. Furthermore, it creates problems with noise pollution,falling nests, and damage to agriculture (Bucher & Bedano, 1976; Bucher & Martin, 1983; Bucher, 1984, 1992; Temple, 1992; Conroy & Senar, 2009).

Although recent data on Monk parakeets show that number of frost days is a limiting factor for their establishment (Strubbe & Matthysen, 2009), the species has been able to adapt to places with a cold climate, such as Chicago, northern New Jersey, and Brooklyn (Pruett–Jones & Tarvin, 1998). It has also successfully colonised temperate areas, such as in Europe. Human activity therefore also appears to be highly responsible for the distribution of the species (Muñoz & Real, 2006; Strubbe & Matthysen, 2009). Their success as an invasive species provides the opportunity to examine adaptation not only to new habitats and environments, but also specifically to crowded cities (Burger & Gochfeld, 2009).

To date, however, studies on the patterns and key variables responsible for the distribution and successful spread of the Monk parakeet have been based on large geographic areas (Muñoz & Real, 2006; Strubbe & Matthysen, 2009). Although the role of cities is very important in the spread of this species (Pruett–Jones & Tarvin, 1998; Burger & Gochfeld, 2009), available data about the variables responsible for the success of the species within cities is scarce. Barcelona city holds one of the largest populations of Monk parakeets in Western Europe (Domènech, 1997; Domènech et al., 2003). The bird was detected for the first time in 1975 in the Ciutadella Park (Batllori & Nos, 1985) and since then, the species has dramatically increased its populations and has expanded its range throughout the entire city (Clavell et al., 1991; Domènech, 1997; Sol et al., 1997). In 2001, there were 313 nests in Barcelona (Conroy & Senar, 2009), but by 2010 the number had increased to 650 nests, with 1,876 chambers (J. C. Senar & T. Montalvo, pers. obs.). The aim of this paper was to determine the factors that affect the distribution of the Monk parakeet in Barcelona city so as to obtain information about the habitat preferences of the species within the urban habitat.

Material and methods

Study area

The study was conducted in Barcelona city, in north–eastern Spain. Barcelona has an area of 102.16 km^2, 72.34% of which is built up. It is divided into ten districts, which allows decentralized local administration. Each district consists of several 'barrios' (neighbourhoods). Barcelona has 73 neighbourhoods, each with its own personality, historical tradition, and homogeneous urban structure, making them clearly recognizable. Neighbourhoods are hence our sample unit.

Data on species distribution

A census of Monk parakeet was carried out from October 2009 until March 2010. A group of university biology students in the final year of their graduate programme helped us to take a census of the population of Monk parakeets in the whole city. We visited every street and all green areas within each neighbourhood. We marked the exact position of each nest found, obtaining the coordinates for each one. We also recorded the number of chambers each nest contained, and the tree species or the substrate on which it was built. The nest coordinates were later transferred to the GIS system MiraMon, creating a layer of points representing the nests. This layer was combined with a layer of the neighbourhoods, reverting data to the neighbourhood level. The resulting map allowed us to know the number and characteristics of nests within each neighbourhood.

We used the density of chambers (number of chambers per square kilometre) per neighbourhood to estimate population density of Monk parakeets at each sampling unit, following Sol et al. (1997) and Domènech et al. (2003).

Descriptor variables

Demographic, socioeconomic and urban development data were provided by the Statistics Department at the Barcelona City Council (http://www.bcn.cat/estadistica/angles/index.htm). We used variables created by the Department of Basic Information and Cartography to determine the main characteristics of building volumes and spatial distribution. From all these data, we selected those variables that would most likely affect the distribution of the Monk parakeet and that could better describe the characteristics of the neighbourhoods. These variables included: human population density (PD), the percentage of people over 65 years (PD > 65), the percentage of buildings constructed before 1901 (B < 1901), and the percentage of streets and roads (SR). The main reasons for choosing these variables are explained below. Population density (PD) gives us an idea about how many people inhabit in each neighbourhood. This could be a variable of interest since it has been seen to have a strong influence on feral pigeon density (Senar et al., 2009). The percentage of people over 65 years (PD > 65) was considered because this population group seems to be more likely to feed birds in urban habitats (Montalvo & Senar, pers. obs.). The last two variables were related to urban characteristics: the percentage of buildings constructed before 1901 (B < 1901) shows that old buildings were constructed more closely together with each other, leaving insufficient space between them for urban parks and trees; and the percentage of streets and roads (SR) indicates that neighbourhoods with wider streets could have many more green areas and trees where Monk parakeets could nest and feed. Finally, we should point out that as our study was based on a small–scale distribution of the Monk parakeets, it was pointless to choose climatic, topographic or lithologic variables as other studies have done (Muñoz & Real, 2006).

The Department of Parks and Gardens in Barcelona provided additional variables describing the vegetation in each neighbourhood: percentage of grass area (grass area per neighbourhood; GA), percentage of shrub area (shrub area per neighbourhood: SA), density of trees (number of trees per square kilometre; DT), and percentage of forest area (forest area per neighbourhood; FA). Barcelona has 295 species of planted trees, but only a few are used by parakeets for feeding or nesting (Carrillo–Ortiz, 2009). So as to determine whether the species of trees had any effect on Monk parakeet distribution we classified the trees into three groups depending on the type of fruit that they produced: trees with fleshy fruit (*e.g. Celtis* sp., *Ficus* sp., *Prunus* sp., *Robinia pseudoacacia*), trees with dry fruit (*e.g. Populus* sp., *Tilia* sp., *Tipuana tipu*, *Ulmus* sp.), and trees with conus or strobilus (*e.g. Pinus* sp., *Cupressus* sp., *Cedrus* sp.). We also included the density of *Phoenix* sp. and the density of *Platanus* sp. as independent variables. *Phoenix* sp. is one of the most commonly used trees by parakeets to build nests in Barcelona (Sol et al., 1997). *Platanus* sp. is the most abundant tree in the city and is increasingly being used to build nests (Carrillo & Senar, pers. obs.). Densities were measured as number of trees per neighbourhood in km^2.

Statistical analyses

Because the dependent variables and several of the independent variables did not follow a normal distribution, all the variables were rank transformed (Conover, 1981). We tested the correlation between the different variables to detect any possible colinearity problem. All the correlations were < 0.50, and in most cases < 0.20–0.30. We can therefore be confident that colinearity does not apply to our data. Next, data were introduced in a generalized linear model (GLZ) adjusted to a recent approach based on the Akaike Information Criterion (AIC) (Burnham & Anderson, 2002; Lukacs et al., 2007). The dependent variable (the density of Monk parakeet measured as density of chambers per neighbourhood) and all the explanatory variables were introduced in the model. The eight independent variables were: human population density (PD), percentage of people over 65 years (PD > 65), percentage of buildings built before 1901 (B < 1901), percentage of road system (SR), percentage of grass area (GA), percentage of shrub area (SA), density of trees (DT), and percentage of forest area (FA). Why some neighbourhoods did not have parakeets could be either because the area was not suitable for the species or just that parakeets had not yet colonized it. We thus preferred to restrict our sample size to those neighbourhoods that had already been occupied (*i.e.* number of chambers > 1). This left us with 51 neighbourhoods (N = 51).

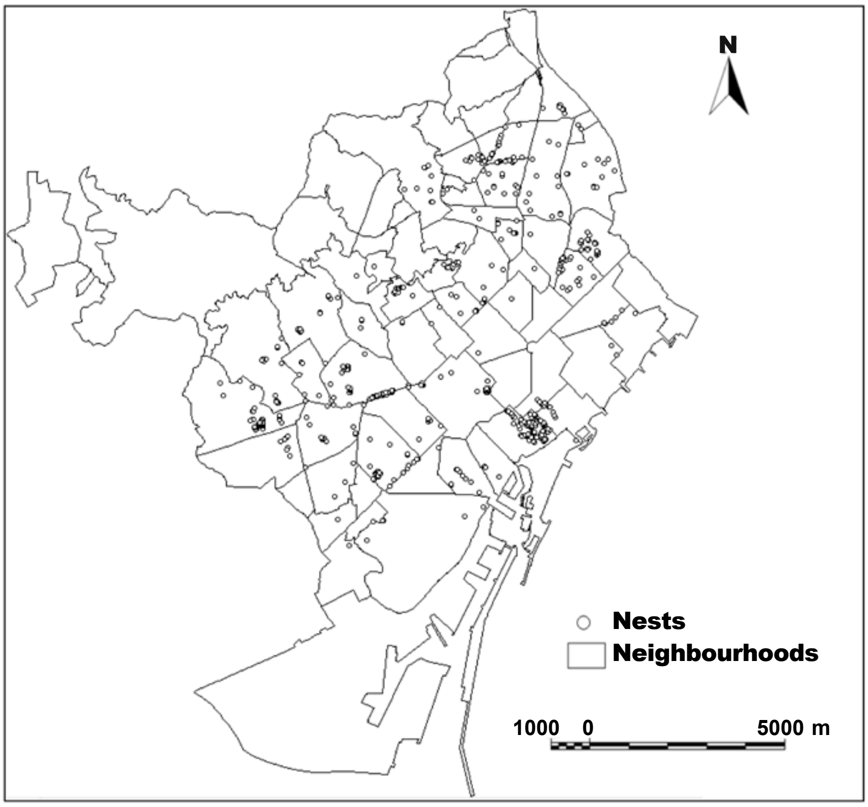

Fig. 1. Distribution map of Monk parakeet nests in the neighbourhoods of Barcelona city. The dots depict the exact localization of the nests.

Fig. 1. Mapa de distribución de los nidos de la cotorra argentina en los barrios de la ciudad de Barcelona. Los puntos representan la localización exacta de los nidos.

As our survey showed that most nests of Monk parakeets were built in palm trees, we decided to additionally test whether the typology of tree species in an area influenced their abundance. We made a multiple regression approach using the density of chambers as the dependent variable, and the density of *Phoenix*, the density of *Platanus*, the density of trees with conus, the density of trees with fleshy fruit, and the density of trees with dry fruit as independent variables. All statistical analyses were carried out using Statistica 10.0 (StatSoft, 2001).

Results

Monk parakeets appeared throughout whole city of Barcelona (fig. 1). The total number of detected nests was 650 and the number of chambers was 1876. The 'Sant Pere, Santa Caterina i la Ribera' neighbourhood had the highest concentration of nests (n = 120), most of which were located within the Ciudadela Park. The average density of nests per neighbourhood in 2010 was 8.27 ± 14.69 (n = 73) and that of chambers was 23.51 ± 38.80 (n = 73) (table 1). Variation between neighbourhoods was high. Five neighbourhoods had a total density of chambers of above 80, most had a density of less than 20 chambers, and almost one third (22 neighbourhoods) had no chambers (figs. 2, 3A).

The size of the nests, computed as average number of chambers per nest and neighbourhood, was also highly variable. In almost half of the neighbourhoods, nests had an average size of one to four chambers, whereas only seven neighbourhoods had smaller nests (average size < 2 chambers), and nine neighbourhoods had the larger nests (average size > 4 chambers) (fig. 3B).

The AIC–based multi–model inference showed that the best model (with the smallest AIC value) regarding the other models consisted of two variables: density of trees (DT) and percentage of people over 65 years (PD > 65) (table 2, fig. 4). The next best model included one further variable: density of human population (PD) (table 2).

A multiple regression analysis relating the preference of Monk parakeet for any type of tree did not show any significant result. Despite the abundance of palm trees and *Platanus* sp. in the city of Barcelona, neither of them affected the density of parakeets (table 3).

Table 1. Descriptive statistics on the density of nests and the density of chambers of the Monk parakeet in Barcelona, both in all neighbourhoods (n = 73) and restricted to neighbourhoods with at least one chamber (n = 51). Density is measured as number of nests or chambers per square kilometre.

Tabla 1. Estadísticos descriptivos de la densidad de nidos y la densidad de cámaras de la cotorra argentina en Barcelona, tanto en todos los barrios (n = 73) como restringido sólo a los barrios con al menos una cámara (n = 51). La densidad es medida como número de nidos y de cámaras por kilómetro cuadrado.

	Valid N	Mean	Median	Minimum	Maximum	SE
Density of nests	73	8.27	3.64	0.00	109.09	1.72
	51	11.84	7.78	0.77	109.09	16.36
Density of chambers	73	23.51	10.00	0.00	233.64	4.54
	51	33.65	16.67	0.77	233.64	42.66

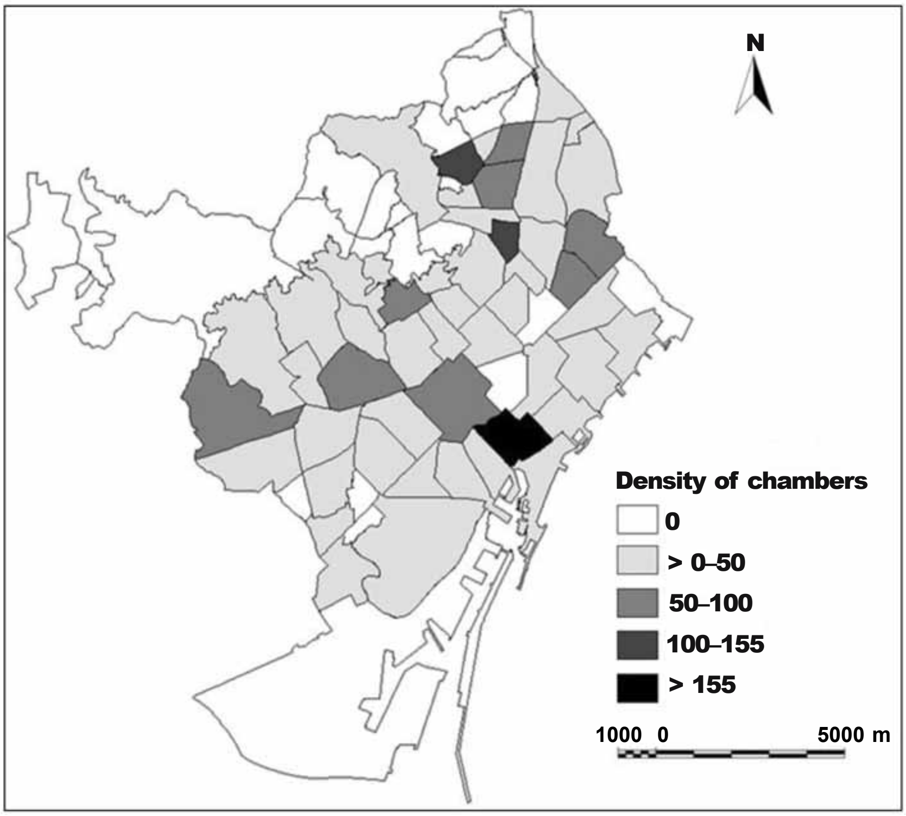

Fig. 2. Distribution map of *Myiopsitta monachus* in Barcelona city. The presence of Monk parakeet measured as the density of chambers (number of chambers per square kilometre) in the different neighbourhoods, where the species was recorded, is categorized in five classes according to a grey scale.

Fig. 2. Mapa de distribución de Myiopsitta monachus *en la ciudad de Barcelona. La presencia de la cotorra argentina medida como la densidad de cámaras (número de cámaras por kilómetro cuadrado) en los diferentes barrios, donde la especie fue registrada, se clasificó en cinco categorías siguiendo una escala de grises.*

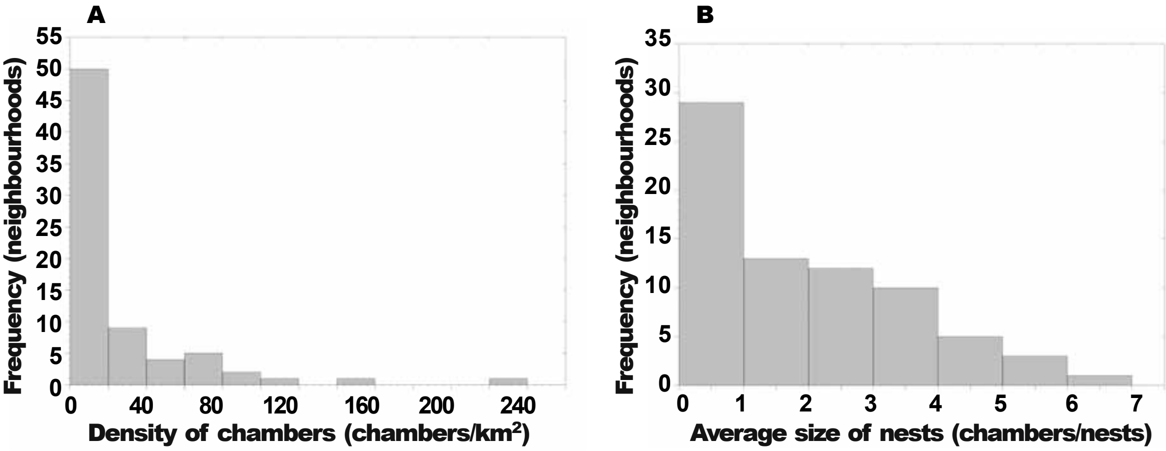

Fig. 3. Frequency distribution of: (A) the density of chambers, and (B) the average size of nests measured as average number of chambers in each neighbourhood in Barcelona (N = 73; 2010 census).

Fig. 3. Distribución de frecuencias de: (A) la densidad de cámaras y (B) el tamaño medio de nidos medido como el número medio de cámaras en cada barrio de Barcelona (N = 73; censo de 2010).

Discussion

Information about the environment in areas of origin of invader species may be important to model their distribution in large, invaded geographic areas (Blackburn et al., 2009). However, it has been recently suggested that the non–native distribution of invading species cannot be predicted from the characteristics of the native niche (Petitpierre et al., 2012). Hence, it becomes highly relevant to obtain

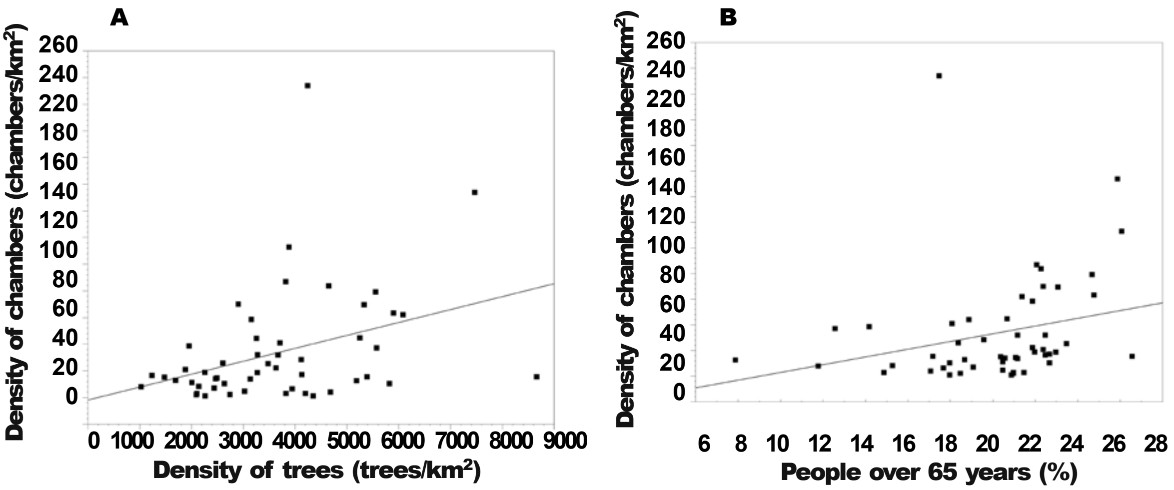

Fig. 4. Relationships between the density of Monk parakeet chambers with: (A) tree density, and (B) the percentage of people over 65 years old. Neighbourhoods with no Monk parakeet nests (# chambers = 0) are not depicted in the graphs. The partial correlations for variables in the multiple regression best model (table 2) were tree density: r = 0.32, *p* = 0.02 and percentage of people over 65 years: r = 0.36, *p* = 0.01.

Fig. 4. Correlaciones entre la densidad de cámaras de la cotorra argentina con: (A) la densidad de árboles y (B) el porcentaje de personas mayores de 65 años. Los barrios sin nidos de cotorras (nº cámaras = 0) no se representan en los gráficos. Las correlaciones parciales para las variables incluidas en el mejor modelo (tabla 2) de regresión múltiple fueron densidad de árboles: r = 0,32, p *= 0,02 y porcentaje de personas mayores de 65 años: r = 0,36,* p *=0,01.*

Table 2. Results of the multimodel inference using AIC to predict which variables in Barcelona city showed the best approximating model that explained the density of Monk parakeets (measured as number of nest chambers): PD. Human population density; PD > 65. Percentage of people over 65 years; B < 1901. Percentage of buildings constructed before 1901; SR. Percentage of streets and roads; GA. Percentage of grass area; SA. Percentage of shrub area; DT. Density of trees; FA. Percentage of forest area.

Tabla 2. Resultados del análisis de inferencia multimodelo basado en el AIC para predecir qué variables en la ciudad de Barcelona definen el mejor modelo que explica la densidad de cotorra argentina (medida como número de cámaras de nido): PD. Densidad de población humana; PD > 65. Porcentaje de personas mayores de 65 años; B < 1901. Porcentaje de edificios construidos antes de 1901; SR. Porcentaje de calles y carreteras; GA. Porcentaje de zonas con césped; SA. Porcentaje zonas arbustivas; DT. Densidad de árboles; FA. Porcentaje de zona forestal.

Step	Models								DF	AIC
1	PD > 65	DT							2	410.24
2	PD	PD > 65	DT						3	410.95
3	PD > 65	FA	DT						3	411.97
4	PD > 65	SR	DT						3	412.03
5	PD > 65	GA	DT						3	412.15
6	PD > 65	B < 1901	DT						3	412.16
7	PD > 65	SA	DT						3	412.21
8	PD	PD > 65	B < 1901	DT					4	412.51
9	PD	PD > 65	SA	DT					4	412.88
10	PD	PD > 65	GA	DT					4	412.91
11	PD	PD > 65	FA	DT					4	412.94
12	PD	PD > 65	SR	DT					4	412.94
13	PD > 65								1	413.49
14	PD > 65	B < 1901	SR	DT					4	413.80
15	PD > 65	B < 1901	FA	DT					4	413.85
40	DT								1	415.42
149	PD	PD > 65	B < 1901	SR	GA	SA	FA	DT	8	420.16
171	B < 1901								1	421.18
181	SR								1	421.89
182	GA								1	422.14
187	PD								1	422.38
197	SA								1	422.97
198	FA								1	422.98

detailed information about the factors responsible for the distribution of these species in invaded areas. In the case of species that are highly linked to urban habitats, like Monk parakeets (Domènech et al., 2003) or House crows *Corvus splendens* (Soh et al., 2002) it becomes imperative to predict their preferences and distribution within cities.We found that the model that best explained the abundance of Monk parakeets in Barcelona city showed two relevant variables: density of trees and the percentage of people over 65 years. The fact that trees are used as a main food source and also to support and build nests (Carrillo–Ortiz, 2009) explains why the density of trees is the main variable to account for Monk parakeet abundance in Barcelona city. Interestingly, our results showed that parakeets had no preferences for different species of trees when selecting preferred 'habitat'. This finding supports a recent study on breeding ring–necked parakeets (*Psittacula krameri*) in Brussels, Belgium, that showed that parakeets preferred to forage in city parks and gardens due to the huge variety of exotic and ornamental plants (Strubbe & Matthysen, 2011;

Table 3. Multiple regression using the different trees grouped by type of fruit that they produce as independent variables. *Phoenix* sp. and *Platanus* sp. were separated from the others because of their abundance.

Tabla 3. Regresión múltiple utilizando los diferentes árboles agrupados por el tipo de fruto que producen como variables independientes. Phoenix *sp. y* Platanus *sp. se separaron del resto debido a su abundancia.*

	Beta	Partial correlation	t(45)	*p*–level
Density of *Phoenix*	0.13	0.12	0.80	0.43
Density of *Platanus*	0.09	0.09	0.57	0.57
Density of trees with conus	–0.10	–0.09	–0.60	0.55
Density of trees with fleshy fruit	0.17	0.15	0.99	0.33
Density of trees with dry fruit	0.22	0.20	1.38	0.17

Clergeau & Vergnes, 2012). Moreover, our finding shows that Monk parakeets in Barcelona currently use other tree species for nesting in cases where palm trees are scarce, which was not the case in the earlier stages of colonization by the species (Sol et al., 1997). In Singapore, Soh et al. (2002) found similar results with another urban invasive bird species, the House crow with regard to the yellow flame trees (*Peltophorum pterocarpum*).

As the Monk parakeet is a colonial species, the stages of colonization can be a consequence of historical and contagious effects (*i.e.,* the occurrence of one nest may prompt the colonization of that area by other individuals of the population). Nevertheless, the average dispersal distance of the species in Barcelona city is 1,114 ± 190 m (Carrillo–Ortiz, 2009), which provides ample opportunities for the colonization of new areas within the city. The presence of a good number of nests with only one chamber supports that this colonization is taking place. Hence, we think that our data reflect habitat selection in spite of historical and contagious effects.

Our data support the 'human–activity' hypothesis to explain how invasive species can successfully establish in a non–native habitat. We found that the percentage of people over 65 years old was an important variable in the best fit model, and the density of human population was strong in the second model (AIC < 2). Human presence thus clearly favours the invasion by Monk parakeets, not only because human activity favours escapes and releases of individuals, but also because of the foraging advantage that individuals enjoy because of (older) people supplying food. Monk parakeets have changed their foraging behaviour in recent years, adapting to novel conditions and using novel resources of food offered by humans (Lefebvre et al., 2004; Sol, 2007). A recent report showed that these new food resources in Barcelona are mainly cereals and bread, and they account for up to 40% of parakeet food sources (Carrillo–Ortiz, 2009). The population group most likely to feed birds is usually retired people (Montalvo & Senar, pers. obs.). Similarly, Pithon (1998) observed that parakeet densities in the UK correlated highly with densities of detached and semi–detached houses inhabited by retired people.

Taken together, our results support the view that the preference and success of invasive species in cities is related to the abundance of food available and nesting sites in these anthropogenic habitats, so that invasive species can easily increase both breeding success and parental survival (Chamberlain et al., 2009). As food sources play a major role in favouring invasive species in general and Monk parakeets in particular, we propose that limiting food resources provided by the population would be a reasonable way to control these species in urban habitats. However, further studies with new variables are needed to understand better and determine why Monk parakeets prefer these areas in Barcelona city.

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