Population increase of the invasive red–whiskered bulbul *Pycnonotus jocosus* in Valencia, Spain

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Abstract
Population increase of the invasive red–whiskered bulbul Pycnonotus jocosus *in Valencia, Spain*. The red–whiskered bulbul *Pycnonotus jocosus* is a medium–sized passerine that has been classified as an invasive species because of its impact on native ecosystems. It was first reported in the Canary Islands of Spain in 1997. In March 2003, it was sighted in the province of Valencia, in eastern Spain, in a residential area called 'La Cañada'. From 2015 to 2020 we monitored its population in a suburban area close to La Cañada using point counts every spring. Since 2015, the population has shown a trend towards a significant increase in this area, with an estimate of (2,428 < 2,878 < 3,412) individuals in 2020. Its frequency of occurrence has also increased, and it appears to have a continuous distribution in the study area. In the last 17 years the red–whiskered bulbul has spread as far as 20 km from La Cañada, and it is expected to continue spreading and increasing in numbers, with consequences as yet unknown.

Key words: Abundance, Colonisation, Density, Dispersion, Invader

Resumen
Población en aumento del invasor bulbul orfeo Pycnonotus jocosus *en Valencia, España.* El bulbul orfeo *Pycnonotus jocosus* es un paseriforme de talla mediana que se ha clasificado como invasor debido a su impacto en los ecosistemas invadidos. En marzo de 2003, esta especie fue vista por primera vez en una urbanización llamada La Cañada, en la provincia de Valencia, al este de España. Hicimos un seguimiento de su población en una zona suburbana cercana a La Cañada utilizando puntos de conteo realizados todas las primaveras entre 2015 y 2020. Desde 2015, la población del bulbul orfeo ha mostrado una tendencia creciente significativa en el área muestreada y se estima que, en 2020, llegó a los (2.428 < 2.878 < 3.412) individuos. Además, también aumentó su frecuencia de aparición, y se supone que sigue una distribución continua en el área de muestreo. La especie no se ha quedado restringida y se ha expandido hasta 20 km desde La Cañada en 17 años. Se prevé que la población de bulbul orfeo continuará aumentando y expandiéndose, con consecuencias aún desconocidas.

Palabras clave: Abundancia, Colonización, Densidad, Dispersión, Invasor

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Introduction

The population of invasive species is expected to fit a logistic curve, with a slow population growth in early stages of the invasion, followed by an exponential increase and a slowdown (Blackburn et al., 2009; Davis, 2009; Lockwood et al., 2013). Biological invasions are the result of intentional or unintentional translocation of species beyond their natural distribution range, with numerous well–known examples (Savidge, 1987; Ram and Palazzolo, 2008; da Silva et al., 2010; Standfuss et al., 2016; Linz et al., 2018). There are generally four main stages in a biological invasion pathway: transport of a species out of its native range, deliberate or accidental introduction (i.e. release or escape from captivity), its successful establishment, and its expansion beyond the original area where it was introduced (Blackburn et al., 2009).

Although most introductions on a global scale took place during a period of major European expansion and settlement (Allen and Lee, 2006; Blackburn et al., 2009), the trends of invaders in Europe indicate an increase in the last two to three decades, with the beginning of globalisation, presumably as a response to the increase in and innovation of human transport over time (Kolar and Lodge, 2001; Hulme, 2009; Abellán et al., 2016). In addition, climate change might facilitate the arrival and establishment of new exotic species, and ease the expansion of those already established (Dullinger et al., 2017; Hulme, 2017; Meyerson et al., 2019). Although exotic species do not always have detrimental effects on the new ecosystem (Stromberg et al., 2009; Gleditsch and Carlo, 2011) they can damage human economy and natural systems in many ways (Pimentel, 2005; Scalera, 2010; Pyšek et al., 2020). Regarding exotic bird species, a high percentage come from temperate regions as the result of introduction during European colonisation, mainly for recreational purposes or as a food resource. In addition, it is estimated that more than half of the introductions occurred on islands, more specifically, on Pacific Islands and in Australasia. Invasive bird species often exhibit high productivity, social behaviour, and behavioural flexibility, which, together with other factors, have enabled their success (Blackburn et al., 2009; Sodhi, 2020).

The red–whiskered bulbul *Pycnonotus jocosus* is a medium–sized passerine whose natural distribution range includes part of the Indian subcontinent and South East Asia (del Hoyo et al., 2005). It is widespread in captivity around the world because of its popularity as a cage–bird for singing contests or simply as a pet. Its escape or deliberate release has resulted in its establishment on tropical and subtropical islands, and in continental areas of Africa, Asia, Europe, North America and Oceania (del Hoyo et al., 2005; Downs and Hart, 2020). Evidence suggests that climate and ecological similarities between its invaded habitat and its native habitat, together with its intrinsic species characteristics, such as its capacity for local adaptation, its habitat flexibility and its tolerance to human–altered habitats, have contributed to the species' success (Islam and Williams, 2000; Yap and Sodhi, 2004; del Hoyo et al., 2005; Le Gros et al., 2016). In newly colonised territories, it first appears in anthropic habitats, where it is introduced due to release or escape, usually occupying public or private vegetated locations in suburban areas, such as parks and gardens, as it has done in Florida and California (Hardy, 1973; Carleton and Owre, 1975). Furthermore, it may occupy other human–altered habitats such as fruit orchards. It is also known to venture into areas of native vegetation, and can even establish in these areas. This behaviour has been observed both on islands such as Réunion and Mauritius, and in continents, such as Australia (Mandon–Dalger et al., 1999; Linnebjerg et al., 2009, 2010; Mo, 2015). It seems to prefer lowlands and areas with plentiful resources due to alien plant species (Forys and Allen, 1999; Mandon–Dalger et al., 1999; Clergeau and Mandon–Dalger, 2001; Linnebjerg et al., 2009, 2010). However, it is not limited to such areas and has been found at high altitudes on Réunion (Mandon–Dalger et al., 1999; Clergeau and Mandon–Dalger, 2001) and in native arid habitats of Australia (Mo, 2015).

The red–whiskered bulbul has been classified as invasive because of its impact on its newly colonised ecosystems. Its most important on native habitats is its role as a seed disperser, which can change the composition of vegetation (Corlett, 2017). It can also facilitate the survival and spread of invasive plant species through the 'gut passage effect', which results in an invasional meltdown (Carleton and Owre, 1975; Simberloff and Von Holle, 1999; Mandon–Dalger et al., 2004; Linnebjerg et al., 2009). It is because of this interaction with other exotic species that some authors (e.g. Martin–Albarracin et al., 2015) have classified it as one of the species with the strongest local and global impact. Moreover, the red–whiskered bulbul is considered an agricultural pest for fruit trees in many countries (Carleton and Owre, 1975; van Riper et al., 1979; Mo, 2015). Other threats to native biodiversity are its competition with native and endangered birds species, including other bulbul species (Owre, 1973; Diamond, 1987; Sankaran, 1998; Lever, 2010), predation on native arthropods and reptiles (Diamond, 1987; Lever, 2010), predation on eggs of passerine species (Cheke, 1987; Roberts, 1988; Thibault et al., 2002), and its possible role as a reservoir for malaria (Shehata et al., 2001).

The red–whiskered bulbul was first reported in Spain in 1997 in Tenerife (Canary Islands, Spain) by Abellán et al. (2016), and its breeding was reported in 2001 by Lorenzo (2007). No further information about its progress and current status in Tenerife is available. Between 2000 and 2021 there have been several sporadic observations of the species in Valencia, Alicante and Granada in Spain, and in Lisbon, Portugal, presumably as a result of independent introductions in the two countries (eBird, 2021; Ascensão et al., 2021). The earliest observation in Valencia was in March 2003, by A. Gil–Delgado and J. S. Monrós, who noted the species in a residential area (La Cañada, Paterna 39º 31' 45.84'' N; 0º 29' 08.26'' W). Its population seems to have increased herein and expanded to nearby areas up until 2010, when one of our team (J. A. Gil–Delgado) observed its presence in a residential area of l'Eliana 39º 33' 51.12'' N; 0º 33' 01.94'' W, where we decided to conduct our study. Its introduction was possibly due to its popularity as a cage–bird in Spain, with its subsequent release or escape from captivity. Since its inclusion in the Catalogue of Invasive Alien Species of Spain, the species has been submitted to all the measures listed in the corresponding laws, including a ban on its possession, transportation, trafficking, and trade. The probability of new introductions into other parts of Spain is therefore low (Cardador et al., 2019). It is not included in the List of Invasive Alien Species of Union concern, but according to Carboneras et al. (2017) its assessment is of mid–priority. Such assessment, however, should have been conducted in 2020 in view of its high impact and the medium level of uncertainty we are facing regarding the outcome of this species in Europe. Despite some information gathered from sightings (Santos, 2016; T. Polo, M. Ferrís, M. Polo, pers. comm., 2021), no single study about the species has been conducted in Spain to check its population status and expansion in the Valencia province. In general, very little it is known about the species in this territory, despite the danger it represents (van Riper et al., 1979; del Hoyo et al., 2005; Lever, 2010). Using data since 2015, we describe and discuss its population status and expansion process in the past few years. The monitored population has either stabilised or it is increasing, showing changes due to readjustments for carrying capacity.

Material and methods

Study area

The study area is located in Valencia (39º 28' 11.1'' N; 0º 22' 38.6'' W), a coastal province in eastern Spain. Due to a demographic increase, municipalities have been transformed by urban growth and residential areas have proliferated. This area has been transformed into a mixture of natural and human–modified patches of Mediterranean vegetation, permanent and annual crops, tree groves, and urban and suburban areas. The red–whiskered bulbul is believed to have spread to suburban areas and artificial vegetated locations near La Cañada (fig. 1). Suburban areas and residential areas are herein used as synonyms, both understood as areas with low population density associated with artificially vegetated areas (e.g. private gardens and urban parks).

The point counts carried were conducted in the area where the red–whiskered bulbul was first observed outside La Cañada in 2010, a residential area of 1,052.25 ha that includes four municipalities of Valencia: l'Eliana, La Pobla de Vallbona, Riba–roja del Túria and San Antonio de Benagéber (fig. 1). This area from here on will be referred to as the sampled area. Other suburban areas outside the sampled area, except for La Cañada, are mentioned as extralimital areas for the purpose of simple reference.

Density and population trend

We determined the density of the red–whiskered bulbul using point counts (Blondel, 1969; García and Purroy, 1973; Sutherland, 2006; Buckland et al., 2015). To calculate density, frequency of occurrence (i.e. number of point counts with the presence of individuals) and population trend, we used a database from 2015–2020. This database consisted of 40 randomly distributed point counts that we repeated each year in spring (April and May). However, given some difficulties during counts (e.g. car traffic or construction site noise), it was not possible every year to perform all the points, but each one has a minimum of 30 and a maximum of 40 points. This means that even if the total number of points counted was 30 one year and 30 again the next, the location of these points could be different from year to year within the initial 40 points (fig. 1). Point counts should be separated by a minimum of 150 m according to Sutherland (2006); but in our case the distance was greater, since our minimum distance between points was 200 m. In addition, we controlled the maximum distance at which we could audibly detect singing individuals. For this environment (i.e. suburban areas) we developed a method to measure our hearing ability. Hearing ability is defined as the distances at which individuals can be detected by participating observers. It was measured by one observer (A) who stood next to a singing red–whiskered bulbul individual to ensure that the individual was in fact singing, while the other observer (B) walked to the maximum distance at which they (observer B) could still hear the individual. Coordinates of the locations of both observers were taken and the distance between them was measured. Moreover, the hearing ability of both observers was tested in order to rule out bias in the results, since two different observers conducted the point counts. For each point count, bird abundance was obtained inside a space limited by a 50–metre radius, and was recorded by a single observer for 5 minutes, with a waiting time of at least 1 minute before the count. Of the birds located within 50 m of the observer, 90 % were seen and heard at the same time, due to the species' habit of perching on high spots to sing. Singing territorial males were counted as two to better estimate the whole population. Counting and waiting time were selected according to the species' singing characteristics. Singing time was defined as the time it took a red–whiskered bulbul individual to sing once the observer arrived at the counting point. It was measured by counting the time it took an individual to start singing at any one of 64 independent randomly selected points in the sampled area. After the observer had localised an individual, they waited at least 1 minute before starting to count. The count was stopped when the individual started singing. Time was recorded as seconds with a chronometer. Once again, these measurements were taken under the same conditions as the point counts to reduce any probability of disturbances, and they were used to set the waiting and counting times for the point counts. Counts started at 8 a.m. and continued to 11 a.m.

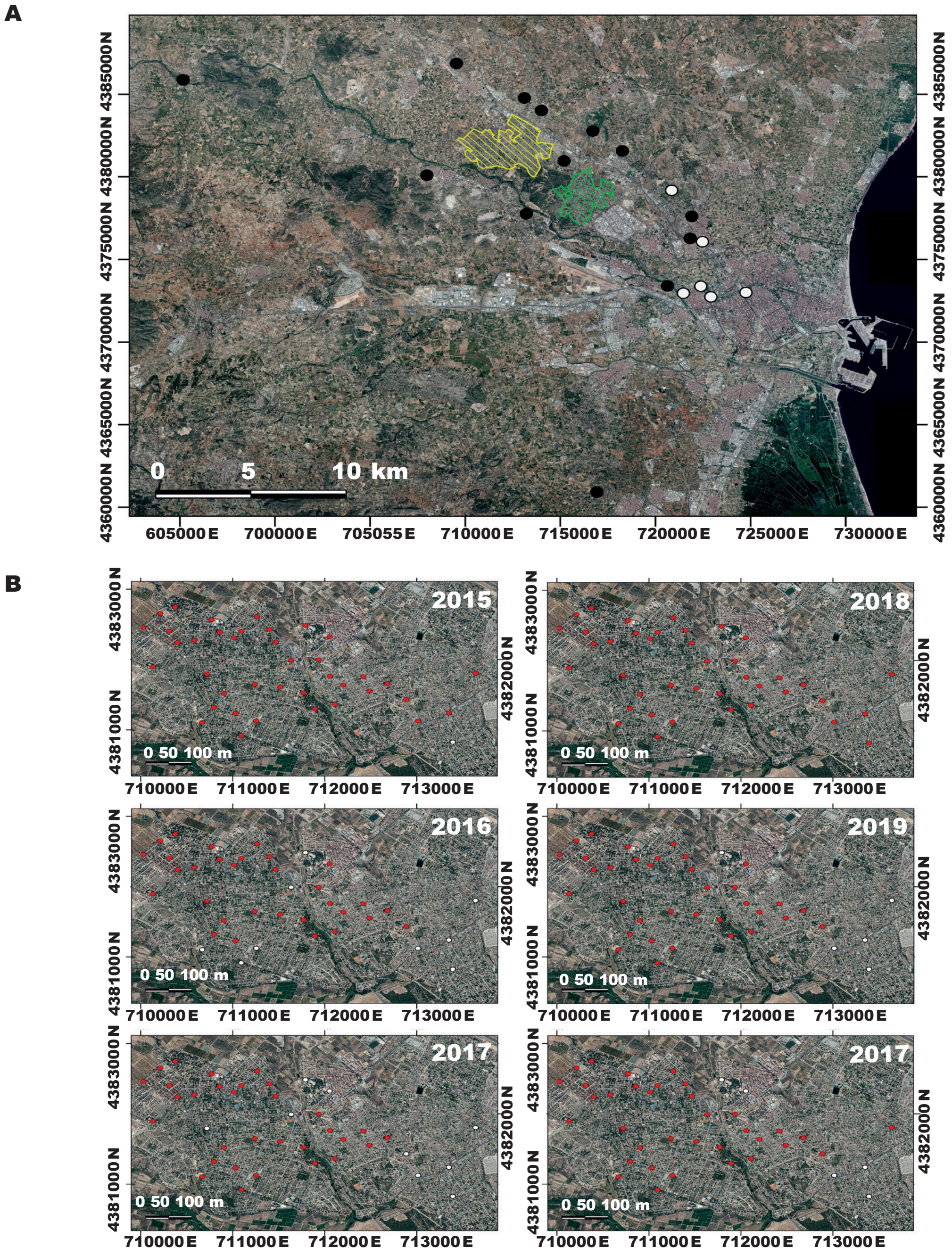

Fig. 1. Location of the range expansion of the red–whiskered bulbul in Spain: A, area in the Valencia Community, eastern Spain, where the red–whiskered bulbul is found. The sampled area (yellow), La Cañada (green), and extralimital locations where presence of the species has been confirmed by observations of the authors (black dots) or from the literature (Santos, 2016; T. Polo, M. Ferrís, M. Polo, pers. comm., 2021) (white dots). B, the 40 points used in the density analysis (2015 and 2020) in the sampled area; the points with presence each year (presence, red dots; absence, white dots).

Fig. 1. Localización del rango de expansión del bulbul orfeo en España. A, territorio en la Comunidad Valenciana, al este de España, donde el bulbul orfeo está presente. Se indican el área muestreada (en amarillo), La Cañada (en verde) y las zonas fuera del área muestreada donde la presencia de la especie se confirmó mediante observaciones de los autores de este estudio (puntos negros) o solo por la bibliografía (Santos, 2016; T. Polo, M. Ferrís, M. Polo, pers. comm., 2021) (puntos blancos). B, los 40 puntos utilizados para el análisis de la densidad (2015 y 2020) en el área de muestreo, con los puntos con presencia para cada año (presencia, puntos rojos; ausencia, puntos blancos).

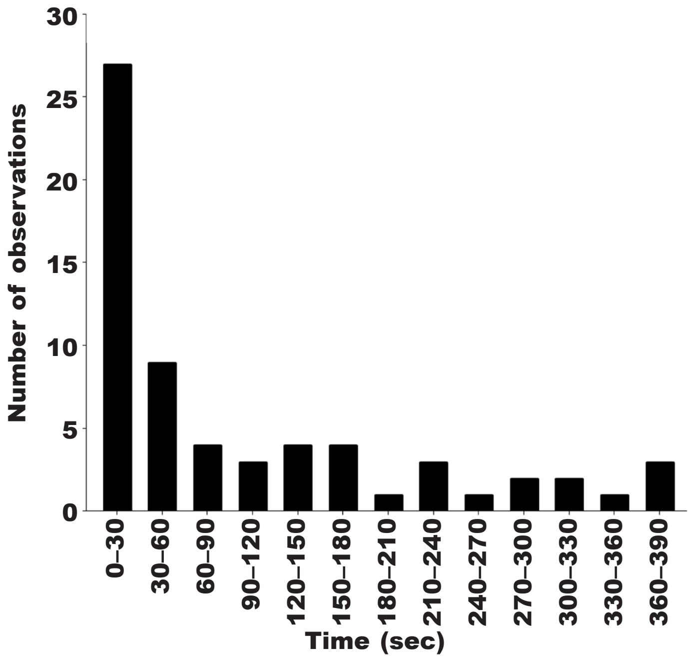

Fig. 2. Results of the time (sec) of each sample taken in the study area regarding the time each individual took to start singing, with the number of observations per category ($R^2 = 0.697$, $F_{1,11} = 11.53$, $p = 0.0025$).

Fig. 2. Resultados del tiempo (en segundos) de cada muestra realizada en el área de estudio que tardan los individuos de esta especie en comenzar a cantar, con respecto al número de observaciones de cada categoría ($R^2 = 0{,}697$; $F_{1,11} = 11{,}53$; $p = 0{,}0025$).

to increase the detection probability (Sotthibandhu, 2003). Counts were avoided on rainy and windy days, and were conducted at weekends or during holidays to reduce the probability of disturbances that could interfere with acoustic detection. Although the species was not actively monitored in the extralimital areas, its presence has been confirmed by independent observations since 2015.

Statistical analysis

The frequency of occurrence was tested using a binomial regression (glm) function (Hastle et al., 1992; Venables and Ripley, 2002). The population trend was analysed using a linear model (lm) function (Wilkinson and Rogers, 1973; Chambers, 1992), with a polynomial regression model, applying the (lm(y~x + I(x^2))) function as the goodness–of–fit measure for the time at which individuals started singing. Hearing ability was tested using a two–sample *t*–test. All the previous statistical analyses were performed with RStudio 1.3.1093.

The density and detection probability of the red–whiskered bulbul was estimated using models based on distance sampling (Buckland et al., 2015) with the Distance 7.3 software (Thomas et al., 2010). Detection probability was modelled from a detection function (g(r)), which represents the probability of detecting an object at a distance (x) from the sampling point (Buckland et al., 1993, 2015; Buckland, 2006). These functions are formed by a key function and its fitting terms (Buckland et al., 1993; Buckland, 2006; Thomas et al., 2010). In this case, the key functions tested were half–normal (hn) and hazard–rate (hr), finally choosing hn because of its lower AIC (indicated in the annexes). Thus we estimated density according to these premises: (i) the individuals at distance 0 were certainly detected, (ii) individuals were detected at their initial point; (iii) the distance between individuals and the observer was accurate between the two groups, considered to be 0–50 m and 50–100 m (Buckland et al., 1993; Buckland, 2006); (iv) detections were statistically independent (Groom et al., 2007). The result of its population density is given as $A < \hat{N} < B$ ind/ha, where *A* represents the minimum value adopted by the population, *B* the maximum value and $\hat{N}$ the best estimate. A transformation from density (ind/ha) to total individuals in the sampled area was applied for ease of interpretation based on Buckland (2006) and their distance sampling method, where individuals were calculated using each density applied to the whole sampling area (1,052.25 ha). We understood population growth rate as the intrinsic rate of increase (*r*) (see Margalef, 1974), where N_t is the final population, N_0, the initial one, and t represents time: $N_t = N_0 e^{rt}$.

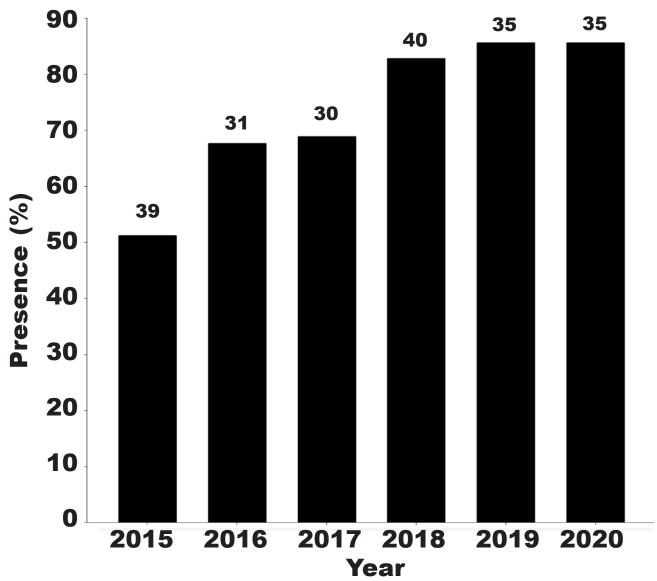

Fig. 3. The point counts with presence of red–whiskered bulbul showed a significantly increasing tendency, i.e. frequency of occurrence (presence %), each year. The exact number of point counts conducted annually is shown at the top of each bar (p = 0.0001).

*Fig. 3. Tendencia significativamente creciente del número de puntos de conteo con bulbul orfeo, es decir, frecuencia de aparición (presence %) de cada año desde 2015 en el área muestreada, con el número exacto de puntos de conteo realizados cada año en la parte superior de cada barra (*p *= 0,0001).*

Results

Hearing ability

Thirty–six distances (half by each observer) were measured around the sampled area. The two–sample t test showed no difference between the means of each observer (O_1= 89.4 m, SE = 1.98; O_2 = 90.2 m, SE = 2.21; t = 0.28099; p = 0.7804). The maximum distance at which an individual could be heard by the observers was 105 m.

Time to start singing

The number of individuals that started singing decreased significantly over time (R^2 = 0.697; $F_{1,11}$ = 11.53; p = 0.0025). Therefore, it took a short time for individuals to be detected, with 42 % being detected within 0–30 seconds. Furthermore, 16 % individuals began singing at 0 seconds. This means that individuals were already present during the waiting time or before sampling commenced (fig. 2). Moreover, only 10 % of individuals took more than 5 minutes to start singing. The mean waiting time was 97 seconds, which validated a 5–minute sampling time (SE = 14.3; N = 64).

Density and population trend

Since the first observation of the red–whiskered bulbul in the sampled area in 2010, its frequency of occurrence has increased significantly (R^2 = 0.8512; $F_{1,4}$ = 29.6; p = 0.005). In 2015, just over 50 % of points were occupied, but this rose to 85 % in 2019 and remained the same in 2020. Therefore in five years, its frequency in the sampled area has increased by 35 % (fig. 3).

The red–whiskered bulbul population density in the sampled area also showed a marked increase. The highest recorded density was in 2020 (2.31 < 2.74 < 3.24 indiv/ha), 0.93 indiv/ha more than the density recorded in 2015 (table 1). Furthermore, its trend showed a significant increase (R^2 = 0.8411; $F_{1,4}$= 21.18; p = 0.01) (fig. 4A). We estimated that the population counted in 2015 with (1,581 < 1,900 < 2,282) individuals in the sampled area had reached (2,428 < 2,878 < 3,412) individuals in 2020. We estimated a total rate of growth of 15 %, a mean growth of 4.15 %, and a variance of ± 0.76 % in the six years we monitored the population in the sampled area (fig. 4B)

Since 2015, independent first–hand observations have been made in different years, seasons and locations in extralimital areas within a 24–km radius of La Cañada. Due to variability in conditions, they were not considered in our study to calculate both population density and trend. However, this has allowed us to confirm the presence of this species in some extralimital areas (fig. 1).

Discussion

Many bulbul species are very vocal and their singing is sufficiently distinctive to be differentiated from sound–similar species (Lloyd et al., 1996; Woxvold et al., 2009; Kamtaeja et al., 2012). Vocalisations vary according to their purpose, and are more abundant during the breeding season, the period when we carried out our sampling (Islam and Williams, 2000; del Hoyo et al., 2005; Kamtaeja et al., 2012). Moreover, species of the genus *Pycnonotus* look for prominent perches to sing on (del Hoyo et al., 2005). They are therefore conspicuous and easy to detect, and the red–whiskered bulbul is no exception. In studies about this species as an invader, its presence is usually identified by sightings or by their song (Carleton and Owre, 1975; Mandon–Dalger et al., 1999; Mo, 2015). Their song is quite particular and cannot be confused with that of other species. When their presence abounded, our results showed that this species was very easily seen or heard, meaning its presence and abundance can be easily controlled.

An increase in presence frequency and population density suggests that the population has increased as both these factors have grown significantly, not only regarding numbers of individuals but also regarding the extent of the area occupied over the years in the study area. Taking into account its presence in the nearby extralimital areas we can assume that its distribution will continue to extend in our study area.

Table 1. Calculations of numbers of individuals in the sampled area (1,052.25 ha) and the corresponding density.

Tabla 1. Resultados de los cálculos para determinar la cantidad de individuos en el área muestreada (1.052,25 ha) y la densidad correspondiente.

Year	Calculations	A	N	B
2015	Density	1.50	1.81	2.17
	Individuals	1,581	1,900	2,282
2016	Density	1.91	2.29	2.75
	Individuals	2,008	2,409	2,890
2017	Density	1.52	1.87	2.30
	Individuals	1,598	1,965	2,416
2018	Density	1.87	2.20	2.58
	Individuals	1,968	2,312	2,715
2019	Density	1.94	2.30	2.73
	Individuals	2,038	2,420	2,874
2020	Density	2.31	2.74	3.24
	Individuals	2,428	2,878	3,412

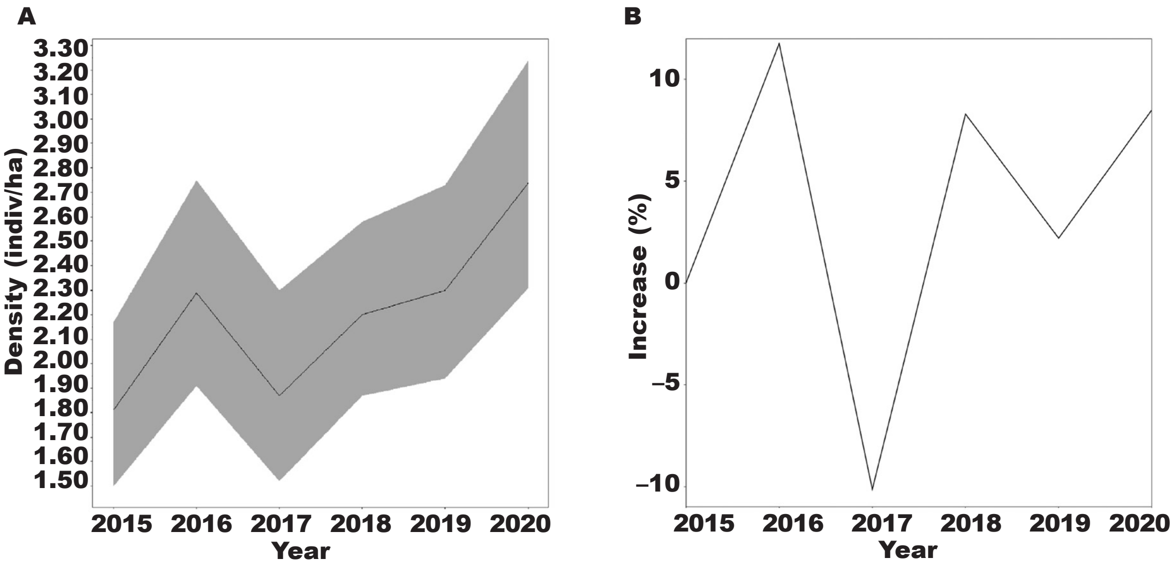

Fig. 4. A, trend in the population density of red–whiskered bulbul (2015–2020) in the study area using Distance Sampling (R^2 = 0.8411; $F_{1,4}$ = 21.18; p = 0.01). Values (ind/ha ± SE). B, annual growth rate (%) of the population density in the sampled area (2015–2020) (R^2 = 0.5354, $F_{1,4}$ = 6.762, p = 0.06).

Fig. 4. A, tendencia de la densidad poblacional del bulbul orfeo (2015–2020) en el área muestreada usando Distance Sampling (R^2 = 0,8411; $F_{1,4}$ = 21,18; p = 0,01). Valor (ind/ha ± EE). B, tasa de crecimiento anual (%) de la densidad poblacional del bulbul orfeo en el área muestreada (2015–2020) (R^2 = 0,5354; $F_{1,4}$ = 6,762; p = 0,06).

One aspect supporting our finding that the bulbul currently occupies the entire sampled area is that the number of point counts where it has been observed has reached 85 % in recent years, a figure similar to the number of individuals detected in 5 minutes. Even when the species is present in the whole area, the result is not likely to be 100 % because some individuals may sing after 5 min, which was the unit of time used to calculate density.

Throughout the six years of this study the red–whiskered bulbul population not only increased in number but doubled in number, matching the expected development of an invasive population. As the percentage of increase from 2015 to 2018 was more pronounced than that in 2019–2020, the population may be approaching carrying capacity (i.e. the k–value) (see Margalef, 1974). This rapid increase is not an obstacle for the population to adjust to a stable pattern, a fluctuating pattern, or to collapse and disappearance (Simberloff and Gibbons, 2004; Simberloff and Rejmánek, 2011; Blackburn et al., 2009). However, between the fluctuating or stable alternatives, the first option seems more probable due to the species invasive nature. The fluctuation can be partly explained by migration towards extralimital areas (Begon et al., 2006; Blackburn et al., 2009). Because the population has been monitored for a relatively short period, we must wait a few more years to see how it progresses, but based on its development in other invaded areas (Islam and Williams, 2000; Clergeau and Mandon–Dalger, 2001; Pranty, 2010; Mo, 2015), we suspect that this species, far from disappearing, will continue to extend. In view of the current prohibitions of alien species in Spain, however, it is unlikely that new introductions will reinforce the established population in Valencia.

In 2017, we observed a decrease in the number of individuals. Although this was not significant, it was abrupt. The number of samples and presence frequency of the species were similar to those recorded in 2016. Other bulbul species show seasonal fluctuations due to local migration or other causes (Monadjem, 2002; Yamaguchi, 2005; Nakamura, 2007), and even invasive bulbuls display this behaviour in invaded areas (Brooks, 2013). In these locations, maximum density peaks are usually reached in spring–summer, when the number of individuals is larger due to seasonal migration or their behaviour fosters detection probability (Nakamura, 2007; Brooks, 2013). Due to the conditions of our sampling, the observed variation cannot be due to these seasonal changes. Therefore, we suspect that it may have been the result of some particularly adverse condition in 2017, or from a drop following exceptionally good conditions in 2016, which we are unaware of.

Our results are consistent with those obtained in other studies of invasive red–whiskered bulbul populations. Carleton and Owre (1975) estimated that the population in Florida in 1969 (nine years after its introduction) would have been about 250 individuals spread over 8.3 km^2, with an approximate average annual population rate increment of 33–40 %. Pranty (2010) pointed out that the red–whiskered bulbul currently occupies an area of 41.7 km^2 in Florida. Although no exact or recent data are available, some authors indicate that its population could have exceeded 700 individuals in the 1980s (Rand, 1980; Pranty, 2010). The rising number of individuals in our study seems similar to that of the species in Florida, with similar population values, but with a smaller sampled area and lower average annual percentage in growth rate. In Australia, Wood (1995) calculated an average density of 0.4 indiv/ha of the red–whiskered bulbul in 37.8 ha in 1985. Considering that the red–whiskered bulbul first arrived in the area where this count was conducted in the 1950s (Mo, 2015), the average annual number of individuals reached 15 individuals in 26–35 years. This figure is lower than ours, although the area was larger. However, even with only 15 individuals, the species was able to continue spreading southwards until the 1990s (Mo, 2015), so its invasiveness should not be underestimated.

One study that calculated dispersion rates of red–whiskered bulbul (Clergeau and Mandon–Dalger, 2001) noticed spread was faster on islands than in continents, as supported by their observation that the rates after 3 years on Mauritius, Réunion and Oahu were higher than those after 10 years in Florida and Australia. Here we confirm the presence of the red–whiskered bulbul in several municipalities outside La Cañada. In 17 years it has expanded from its origin of release to residential areas within a 20–km radius. Our results can therefore be compared to the dispersal rates observed in Florida and Australia. Its different expansion on different continents could be attributed to species diversity, established interaction networks, predation, competition with other invasive species, and geographical and other ecological characteristics such as habitat suitability (van Riper et al., 1979; Williams and Giddings, 1984; Mandon–Dalger et al., 1999; Islam and Williams, 2000; Clergeau and Mandon–Dalger, 2001; Mo, 2015). It remains to be determined how these aspects may affect the species in the province of Valencia, Spain.

The expansion and colonisation of the red–whiskered bulbul in Valencia has been ignored for too long. Human intervention is most effective in early stages of invasion when the number of individuals is still small. We therefore need to know how much time there is before we reach the point of no return regarding this invasion (Clergeau and Mandon–Dalger, 2001; Blackburn et al., 2009; Davis, 2009; Lockwood et al., 2013). Eradication programmes in California have been unsuccessful as individuals continue to exist in the area (Owre, 1973; Islam and Williams, 2000; Lever, 2010). However, the programmes conducted on the Seychelles Islands by the Seychelles Island Foundation (SIF) in 2013–2014 seem to have worked as there has been no trace of the species since 2015 (Rimbault et al., 2017). It is of note that the characteristics of these two regions differ (eradication on an island versus eradication on a continent), and this could have influenced the different outcomes. Until more data become available concerning the ecology and impact of the red–whiskered bulbul the extent of the threat of the invasive species remains unknown.

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