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Striking resilience of an island endemic bird to a severe perturbation: the case of the Gran Canaria blue chaffinch

Á. C. Moreno, L. M. Carrascal, A. Delgado, V. Suárez, J. Seoane

Moreno, Á. C., Carrascal, L. M., Delgado, A., Suárez, V., Seoane, J., 2018. Striking resilience of an island endemic bird to a severe perturbation: the case of the Gran Canaria blue chaffinch. *Animal Biodiversity and Conservation*, 41.1: 131–140.

Abstract

Striking resilience of an island–endemic bird to a severe perturbation: the case of the Gran Canaria blue chaffinch. Evidence regarding population trends of endangered species in special protection areas and their recovery ability from catastrophic disturbances is scarce. We assessed the population trend of the Gran Canaria blue chaffinch (*Fringilla polatzeki*), a habitat specialist endemic to the pine forest of Inagua in the Canary Islands, following a devastating wildfire in July 2007. Using a standardized census program that accounts for detectability, we have monitored the population trend of the species since Inagua was declared a Strict Nature Reserve in 1994. The breeding population density of the blue chaffinch remained stable in Inagua from the beginning of the monitoring program in 1994 until the year before the wildfire. However, in spring 2008, the population density decreased by half with respect to density in the preceding years. Since 2008, the population has gradually increased, reaching its highest recorded density in 2016 (15.8 birds/km^2).This represents an average annual increase of 23.7%, indicating impressive resilience to catastrophic events. The creation of Inagua as a strict nature reserve did not therefore increase the global population or protect the blue chaffinch against a demographic crisis but probably prevented a deepening of the demographic crisis or further declines. Except for the two years immediately after the severe wildfire of 2007, the population density of the blue chaffinch in Inagua has remained relatively stable at around 9–16 birds/km^2, the lowest recorded abundance for a small woodland passerine in the Western Palearctic.

Key words: Blue chaffinch, Canary Islands, Density, Population trend, Strict nature reserve, Wildfire

Resumen

Marcada resiliencia de una especie de ave insular endémica después de una perturbación intensa: el caso del pinzón azul de Gran Canaria. Son pocos los datos disponibles sobre la tendencia demográfica de las especies en peligro de extinción en zonas de protección especial y su capacidad de recuperarse de perturbaciones catastróficas. Se estudia la tendencia demográfica del pinzón azul de Gran Canaria (*Fringilla polatzeki*), un especialista de hábitat endémico de las Islas Canarias, restringido al pinar de Inagua, que sufrió un devastador incendio forestal en julio de 2007. Mediante un programa de censo estandarizado que tiene en cuenta la variación en la capacidad de detección, se ha hecho un seguimiento de la tendencia demográfica de la especie desde la declaración de Inagua como reserva natural integral en 1994. La densidad reproductiva del pinzón azul se mantuvo estable en Inagua desde el inicio del programa de seguimiento en 1994 hasta un año antes del incendio. No obstante, en la primavera de 2008, la densidad de la población se redujo a la mitad en comparación con los años anteriores. A partir de 2008, la población del pinzón azul ha venido aumentando gradualmente hasta alcanzar la densidad más alta jamás registrada en 2016 (15,8 aves/km^2), lo que equivale a un incremento anual medio del 23,7% y pone de manifiesto la resistencia impresionante de estas poblaciones ante catástrofes. Por lo tanto, la creación de la reserva integral de Inagua no promovió el aumento de población ni protegió al pinzón azul frente a una grave crisis demográfica, sino que probablemente evitó que la disminución de la población fuera más profunda o que se produjeran otras reducciones. Aparte de los dos años inmediatamente posteriores al incendio forestal de 2007, la densidad de población del pinzón azul en Inagua se mantuvo relativamente estable alrededor de 9–16 aves/km^2, la menor abundancia jamás registrada para un paseriforme forestal de tamaño pequeño en todo el paleártico occidental.

ISSN: 1578–665 X
eISSN: 2014–928 X

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Palabras clave: Pinzón azul, Gran Canaria, Densidad, Tendencia poblacional, Reserva natural integral, Incendio forestal

Received: 12 V 17; Conditional acceptance: 21 VI 17; Final acceptance: 31 VII 17

Ángel C. Moreno, Dirección General de Protección de la Naturaleza, Gobierno de Canarias, c/ Prof. Agustín Millares Carló 18, 35071 Las Palmas de Gran Canaria, Canary Islands, Spain.– Luis M. Carrascal, Dept. of Biogeography and Global Change, Museo Nacional de Ciencias Naturales–CSIC, c/ José Gutiérrez Abascal 2, 28006 Madrid, Spain.– Alejandro Delgado, Víctor Suárez, Javier Seoane, Terrestrial Ecology Group, Depto. de Ecología, Univ. Autónoma de Madrid, 28049 Madrid, Spain.

Corresponding author: L. M. Carrascal. E–mail: lmcarrascal@mncn.csic.es

Introduction

Resilience against critical events is a scarcely studied but important matter, especially in endangered species. From 1994 to 2004, Butchart et al. (2006) documented the relative success of conservation efforts that prevented sixteen bird species from becoming extinct. Many of them were threatened birds inhabiting oceanic islands, with very low populations restricted to single, discrete sites. The main sources of extinction risk in these circumstances were related to habitat loss and degradation, deleterious effects which were reduced or eliminated through habitat protection, management and restoration, especially inside protected areas. Strict natural reserves are established to protect biodiversity, both as a whole and considering those threatened species that face conservation challenges. Nevertheless, the effectiveness of protected areas is a subject of continuous debate and testing to evaluate its success, poor results, or need for improvement (Martínez et al., 2006; Craigie et al., 2010; Gutiérrez and Duivenvoorden, 2010; Cantú–Salazar et al., 2013; Dunn et al., 2016). This is most notably the case when phenomena and processes occurring outside the limits of the protected areas affect the populations within them (e.g., global warming, changes in rainfall regime, emergent diseases, invasive species), and is of concern for species with very small ranges, and possibly restricted to a single location. Such conditions attract conservation focus and efforts to declare such areas a reserve. It is therefore important to accumulate evidence regarding whether protected areas for endangered species have contributed to the recovery of their populations, in particular the reserves that are the last shelters for the most narrowly–distributed species (Geldmann et al., 2013). Moreover, considering the low amount of detailed information on particular species regarding how extinctions are prevented, it is necessary to increase our knowledge about their recovery ability after drastic population declines.

The Gran Canaria blue chaffinch (*Fringilla polatzeki*, Canary Islands) is a rare, threatened species that occupies an island–habitat within the island of Gran Canaria (Martín and Lorenzo, 2001 for the probable status of the species since the beginning of the 20th century). Currently split from *F. teydea* according to genetic, morphological and behavioural data (Pestano et al., 2000; Lifjeld et al., 2016; Sangster et al., 2016), it is mainly restricted to the Strict Nature Reserve of Inagua–Ojeda–Pajonales (Inagua, hereafter; 39.2 km^2; Moreno and Rodríguez, 2007), although a few pairs have recently established elsewhere as a result of a translocation program (Delgado et al., 2016). The Gran Canaria blue chaffinch is a habitat specialist of the mature Canarian pine forests (*Pinus canariensis*), likely as a consequence of past competition with other *Fringilla* species and niche displacement (Illera et al., 2016). It nests in tall trees. Breeding success is low for a Fringillidae, with only ca. 1.5 fledglings per successful nesting attempt, and 1.4 clutches per breeding season (Rodríguez and Moreno, 2008; Delgado et al., 2016). The estimated population size (with a previous educated guess at around 300 birds, BirdLife International, 2016) lies within the left tail of the distribution of minimum viable population (MVP) estimates for many species, far from the average MVP of 3,750 individuals for birds (Brook et al., 2006; Traill et al., 2007). This is most notable if we take into account the small size of the species (approx. 30 g), since body mass in birds is usually negatively correlated with abundance or maximum ecological densities in the preferred habitats (Carrascal and Tellería, 1991; Gaston and Blackburn, 2000).

The main goal of this study was to analyse the population trend shown by the Gran Canaria blue chaffinch in Inagua since the forest was declared a Strict Nature Reserve in 1994, the only area in the world where the species was present until then as a regular breeder (Martín and Lorenzo, 2001). If the declaration of this area as a reserve contributed to the conservation of the species, we would expect to find a non–decreasing population trend (either positive or stable annual counts). A wildfire in July 2007 that badly damaged the pine forest of the Inagua Reserve provided an opportunity to quantify how severe fire affected the blue chaffinch population and how it recovered in the following years.

Material and methods

Study area

The study area is located in the Inagua pine forest of Gran Canaria (27º 58' N, 15º 35' W), an island of volcanic origin (1,560 km^2, maximum altitude of 1,950 m a.s.l.; for more details on the vegetation of the island see Santos, 2000). The Inagua Integral Natural Reserve (39.2 km^2, 250–1,550 m a.s.l.; Special Protection Area of the European Union since 1979; see fig. 1) is a mature pine forest that harbours the main extant breeding population of the Canaria blue chaffinch (Moreno and Rodríguez, 2007). This chaffinch is scarce in pinewoods below 1,000 m a.s.l. (Moreno and Rodríguez, 2007). A severe fire in July 2007 badly affected the Inagua Reserve (see fig. 1 in Suárez et al., 2012). The Canary pine has the remarkable characteristic of being able to survive and grow after fire, and thus in most places, pine foliage was partially recovered by June 2008, and the tree foliage showed full growth by the breeding season of 2010. For environmental characteristics of the Inagua pine forest see Rodríguez and Moreno (2008).

Bird census

Data on bird abundance were obtained through line transect sampling in Inagua during the breeding season of the species (the second fortnight in May and the first fortnight in June; see Rodríguez and Moreno, 2008) over 18 years, from 1994 to 2016. We surveyed a fixed net of trails following a single route of a total length of 22.9 km on adequate habitat over the area with the highest density of the species (see fig. 1). Since 1994 we used the same line–transect method. From 1994 to

2008, the route was censused only once per year, but from 2009 to 2016, the transect was repeated three times on different days and bird counts were averaged to assess whether more precise results could be obtained. Transects were carried out on rainless days. Researchers walked slowly (1–3 km/h approximately) along small trails in the first four hours after dawn. The censuses were performed by different people: A. C. M. from 1994 to 2004; L. M. C. and J. S. in 2008; and V. S. and A. D., in 2006, 2009–2016. To account for between–observers and between–year variations in detectability while we used distance sampling methods. For each bird heard or seen, we estimated the perpendicular distance to the observer's trajectory. Previous training helped to reduce between–observer variability in distance estimates. Detection distances were right–truncated as recommended by Buckland et al. (2001), excluding 5 % of birds recorded far away (i.e. beyond 125 m). Four models that are commonly used to explain the loss of detectability as a function of the distance from the transect line were fitted to estimate the probability of detection within strips of width equal to the truncated distance: half–normal and hazard–rate, with the inclusion of polynomial or cosine adjustment terms (Buckland et al., 2007). Models were evaluated according to AICc to obtain model weights. The weighted mean of the probability of detection and the effective strip width were used to estimate population densities from the number of blue chaffinches detected (using Akaike's weights).

Detectability models for the blue chaffinch were built with R version 3.1.2 (R Core Team, 2014) and specialized packages: Distance (Miller, 2016a) and mrds (Miller, 2016b).

Population density and trends

Population density of the blue chaffinch in Inagua was calculated considering the counts of birds in the 22.9 km census route and the effective strip width (ESW) derived from the probability of detection. The total length of transects were divided into 100 contiguous units of equal length (229 m), to which the detected blue chaffinches were assigned in each year. As these one–hundred units are not truly independent samples, a bootstrapping procedure was carried out to estimate the average density and the proper confidence intervals (Davison and Hinkley, 2007). Density for each year in each randomization trial was estimated considering (1) the total number of chaffinches in the bootstrap sample, (2) a random probability of detection obtained from the corresponding 95 % confidence interval for that year (to account for uncertainty in the probability of detection; see table 1), and (3) a strip width of 125 m on both sides of the 22.9 km route. We carried out 20,000 randomizations to estimate population density in each of the 18 years of study. Confidence intervals were obtained using the percentile method, considering the non–Gaussian distribution of density figures.

To assess population trends of blue chaffinch in Inagua, we used the bird counts obtained from 1994 to 2016 within the 100 sample units of 229 m–long transects (we used the counts of one census per year from 1994 to 2008, and the average of three counts from 2009 to 2016). First, we estimated the between–years population changes (byPC) in any two consecutive years *t* and *t+1* as:

$$\text{byPC} = 1 + [(D_{t+1} - D_t) / D_t]$$

with D being the average density in the 100 sample units. Second, we randomly assigned the bird density in each one of the 100 sample units between years *t* and *t+1*, by shuffling the density figures within rows (with sample units as rows and years as columns), and calculated the null between–year population change as presented in the previous step. Note that this randomization procedure preserves the spatial structure of the data, because the shuffling is limited to rows. And finally, this randomization procedure was repeated 20,000 times to obtain the null distribution of population trend figures between consecutive years. The observed population changes between the two years under comparison were tested against the two–tailed 95 %, 99 % and 99.9 % percentiles of the null distributions.

Analyses were carried out using the Bootstrapping, Resampling and Monte Carlo functions of 'PopTools 3.0', http://www.cse.csiro.au/poptools/, run in Microsoft Excel 2010.

Results

Gran Canaria blue chaffinch counts ranged from 17 to 50 individuals over the years, and probability of detection within the 125–m strip width ranged between 0.52 and 0.71 over study periods (table 1). The width of the confidence intervals of bird counts, relative to the average, was lower in years when three repetitions of the censuses were carried out (2009–2016; average relative width = 54.1 %) than in years when only one census was carried out (1994–2008; average = 74.3 %; $p < 0.001$ in the t–test comparing the two census periods; table 2). Thus, three repetitions per year of the same census transect increased the precision of the estimates of average density.

The population density of the blue chaffinch remained stable from the beginning of the monitoring program in 1994 to one year prior to the devastating forest fire in July 2007 (table 2, fig. 2), with an average density of 9.7 birds/km^2 (range of year averages: 8.0–12.7 birds/km^2). Pairwise tests comparing counts on all pairs of years showed that even the peak in chaffinch abundance in 2000 was not significantly different from the other density estimates (55 tests using sequential Bonferroni correction for type I error–wise rate at $\alpha = 0.05$). Population density in spring 2008 (10 months after the forest fire) halved with respect to that measured in 2006 (58 % reduction to 4.8 birds/km^2; $p = 0.001$).

From 2008 onwards, the blue chaffinch population gradually increased, with a significant increase from 2009 to 2010 ($p = 0.005$ that remains significant after a sequential Bonferroni correction of the six tests between consecutive years from 2008 to 2016). The linear correlation between year and population

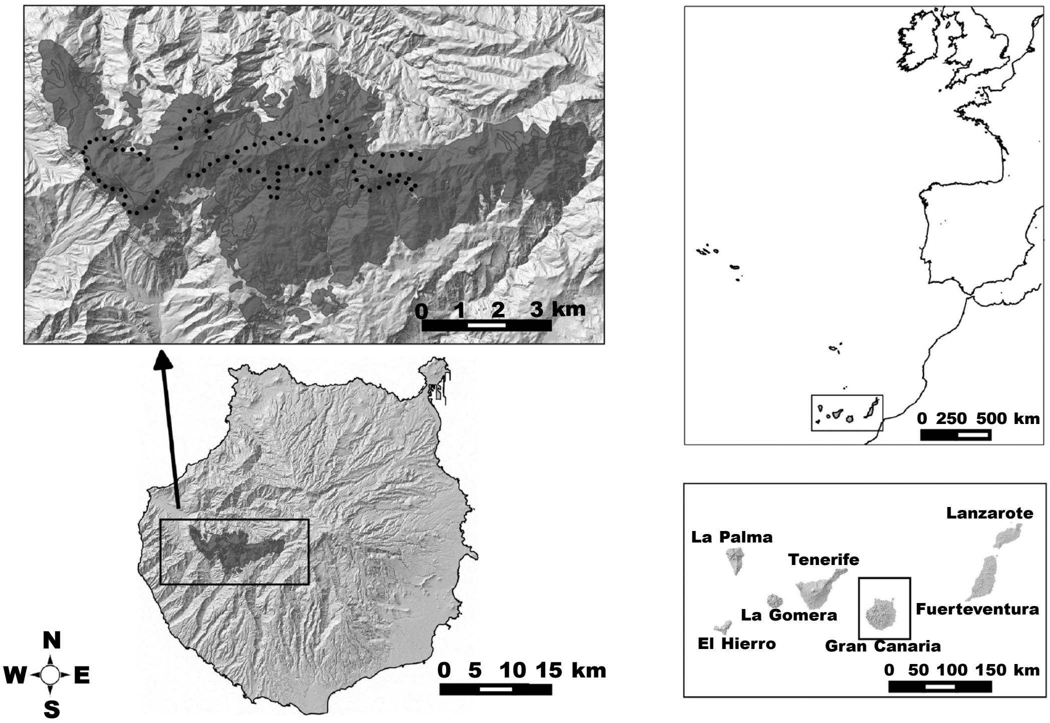

Fig. 1. Study area in Gran Canaria island. Black dots show the centre of 100 units of 229 m in length of a census route of 22.9 km repeated from 1994 to 2016.

Fig. 1. Zona de estudio en la isla de Gran Canaria. Los puntos negros indican el centro de 100 unidades de 229 m de longitud de un transecto de 22,9 km para elaborar el censo que se ha venido repitiendo desde 1994 hasta 2016.

density was high from 2008 to 2016 (r = 0.886, 99 % bootstrapped confidence interval: 0.696–0.988). Population abundance in the last monitoring year, 2016, was higher than any other previous year, with an average density of 15.8 birds/km^2. The percentage of population increase from 2008 to 2016 was 229 %.

To summarize, the population density of the blue chaffinch in the Inagua reserve remained stable at around 10 birds/km^2 from 1994 to 2006, decreased as a consequence of the devastating forest fire in July 2007, remained low during the subsequent two years, and then showed a clear increasing trend during the following eight years, reaching the highest density ever recorded in 2016.

Discussion

The endangered blue chaffinch of Gran Canaria Island has shown a remarkably stable long–term population trend over the last 23 years. Given its scarcity in the past and the extremely restricted distribution area of this species (Martín and Lorenzo, 2001), a strict natural reserve was established in 1994 in Inagua. The devastating forest fire in July 2007 halved the chaffinch population on the island. Nevertheless, it has shown an impressive resilience as the population recovered 3–4 years after the wildfire, reaching the highest population density ever recorded in 2016. Moreover, the demographic bottleneck was not accompanied by a clear genetic erosion, as the blue chaffinch has not experienced a significant decline in allelic richness or an increase in the inbreeding coefficient (Suárez et al., 2012). These results reveal the ability of this endemic chaffinch to survive in these unique forests within the context of the Western Palearctic, and the adaptation of both bird and tree to recovery after wildfires, a common phenomenon in volcanic islands such as the Canary archipelago. The population trend of the species in the Inagua Strict Nature Reserve supports that 'broad and shallow' protection of endangered species, resting only in the passive protection of areas, is less effective than 'narrow and deep' protection, with more financial expenditures, dealing with populations (e.g., Kolecek et al., 2014; Luther et al., 2016), because the creation of Inagua nature reserve did not avoid the wildfire risk for this species. The highly stable population density of the blue chaffinch in the mature

Table 1. Detectability estimates of the Gran Canaria blue chaffinch carried out for different time periods, each with a different team of observers. Bird counts were obtained by distance–sampling over the same fixed route of 22.9 km: Best model, best fitted model with the lowest AIC figure; HNc, half–normal with cosine adjustment; HNp, half–normal with polynomial adjustment; HRc, hazard–rate with cosine adjustment; HRc, hazard–rate with polynomial adjustment); pDET, probability of detection within 125–m strip width (SE, standard error); ESW, effective strip width (in m); #birds, number of bird contacts (also including other contacts obtained censusing other forest tracts in Inagua in 2008).

Tabla 1. Estimaciones de la capacidad de detección del pinzón azul en Gran Canaria realizadas con respecto a períodos distintos, cada una de ellas con un equipo diferente de observadores. Los conteos de aves se obtuvieron mediante un muestreo a distancia a lo largo de la misma ruta establecida de 22,9 km: Best model, mejor modelo ajustado con la menor cifra del AIC; HNc, seminormal con términos de ajuste de coseno; HNp, seminormal con términos de ajuste polinómicos: HNc, tasa de riesgo con términos de ajuste de coseno; HRc, tasa de riesgo con términos de ajuste polinómicos; pDET, probabilidad de detección en una franja de 125 m de ancho (SE, error estándar); ESW, ancho efectivo de la franja (en m); #birds, número de contactos con aves (incluidos otros contactos obtenidos en censos de otros transectos forestales realizados en Inagua en 2008).

Years	Best model	#birds	ESW	pDET	SE pDET
1994–2004	HNc	345	79.3	0.634	0.054
2008	HNc	32	88.3	0.664	0.113
2006, 2009–2011	HNc	265	65.1	0.521	0.047
2013, 2015–2016	HNc	350	69.5	0.556	0.043

pine forest of Inagua may be understood considering long–term stability of this forest habitat, causing places suitable in one year to remain so over many seasons, and to cross–generational reproducibility of the criteria used by birds in their settlement decisions (see also Wesołowski et al., 2015).

Table 2. Bird counts (Bc), and their 95% confidence intervals (L, lower 95%; U, upper 95%), for the Gran Canaria blue chaffinch population in Inagua pine forest during the second fortnight in May and the first fortnight in June, throughout the 18–year study period, from 1994 to 2016. From 2009 to 2016, three censuses were carried per year on different days, while only one census per year was made in the remaining years; rel. width, width of the confidence intervals of bird counts, relative to the average.

Tabla 2. Conteos de aves (Bc) y sus intervalos de confianza del 95% (L, inferior; U, superior) de la población de pinzón azul en el pinar de Inagua, Gran Canaria, durante la segunda quincena de mayo y la primera de junio de los 18 años del estudio, entre 1994 y 2016. Entre 2009 y 2016 se realizaron tres censos anuales en distintos días, mientras que los demás años solo se realizó un censo anual; rel. width, amplitud del intérvalo de confianza, relativa al valor medio del conteo de aves.

Years	Bc	L	U	Rel. width
1994	31	20.0	43.0	74.2
1995	29	17.0	43.0	89.7
1996	29	19.0	39.0	69.0
1997	33	22.0	45.0	69.7
1998	30	19.0	43.0	80.0
1999	36	23.0	50.0	75.0
2000	46	34.0	59.0	54.3
2001	40	26.0	55.0	72.5
2002	33	21.0	47.0	78.8

Years	Bc	L	U	Rel. width
2004	38	26.0	51.0	65.8
2006	34	23.0	46.0	67.6
2008	21	12.0	32.0	95.2
2009	17	12.0	23.0	64.7
2010	29	21.0	37.3	56.3
2011	32	23.7	40.7	53.1
2013	30	21.7	38.3	55.6
2015	37	28.0	45.7	47.7
2016	50	38.7	62.3	47.3

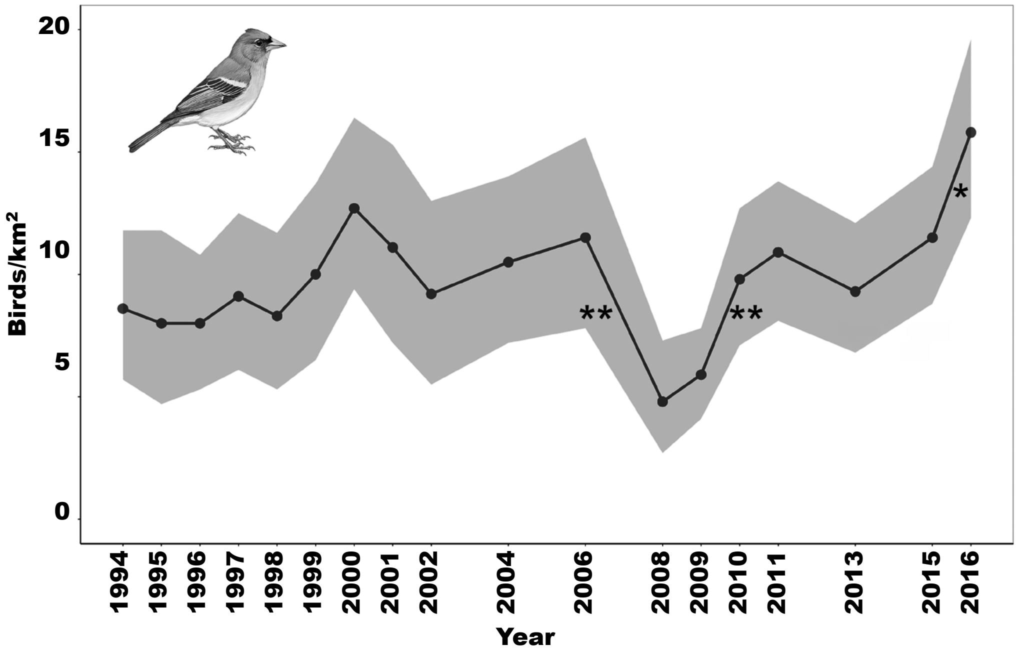

Fig. 2. Temporal variation of the blue chaffinch density in Inagua. Dots and continuous line denote average estimations, while shadow area shows the 95% confidence intervals. Density estimates take into account the probability of detection (within its 95% confidence interval) and the spatial heterogeneity in bird counts along the 22.9 km of the census trail. Asterisks show significant differences between consecutive density estimations after sequential Bonferroni correction (* $P < 0.05$; ** $P < 0.01$). Drawing of blue chaffinch from www.birdlife.org.

Fig. 2. La variación temporal de la densidad del pinzón azul en Inagua. Los puntos y la línea discontinua denotan el promedio de las estimaciones, mientras que el área sombreada indica los intervalos de confianza del 95%. Para calcular las estimaciones de la densidad se tomó en cuenta la probabilidad de detección (dentro de su intervalo de confianza del 95%) y la heterogeneidad espacial en los conteos de aves a lo largo de los 22,9 km del transecto. Los asteriscos indican las diferencias significativas entre estimaciones de densidad consecutivas tras una corrección secuencial de Bonferroni (P < 0,05; ** P < 0,01). Dibujo del pinzón azul extraída del sitio web www.birdlife.org.*

Apart from the two years immediately after the severe forest fire of 2007, the population density of the blue chaffinch in Inagua remained relatively stable at around 10 birds/km^2 within its well–preserved core area (with a maximum of 15.8 birds/km^2). This is one of the lowest ever recorded abundances for a small woodland passerine in the whole Western Palearctic (Hagemaijer and Blair, 1997), and more than four times lower than the maximum densities measured for the other blue chaffinch species in the pine forests of Tenerife Island (*Fringilla teydea*, 69 birds/km^2, Carrascal and Palomino, 2005; 170 birds/km^2, García–del–Rey et al., 2010). Similarly, the endemic Azores bullfinch *Pyrrhula murina*, also an endangered habitat specialist, reaches considerably higher densities of 100–200 birds/km^2 (in native laurel forests of São Miguel Island; Ceia et al., 2009, 2011). This recorded low population density suggests important environmental limitations for the blue chaffinch in the Gran Canaria island, even in its emblematic protected core area.

The historic Gran Canaria pine forests (i.e., not derived from recent plantations), despite some relict populations of high haplotypic diversity (Vaxevanidou et al., 2006), are located in the south–eastern distribution limit of the species, and are probably remnants of larger populations severely reduced by human activities and adverse climatic conditions (precipitation decreases from west to east in the Canary Islands; Marzol, 2000). This is particularly evident for the remnant pine forests located around Tauro, where extremely dry conditions are manifested in symptoms of decay in many individuals (Vaxevanidou et al., 2006). Moreover, this situation will likely worsen as a consequence of climate change in the Canary Islands, where models predict increases in temperature and a decrease in precipitation over the next 85 years (Morata, 2014; Expósito et al., 2015). Warming has been more evident at high mountains than at lower altitudes in both Tenerife and Gran Canaria islands since 1970 (0.16 °C/decade; Martín et al., 2012; Luque et al., 2014). Recently, Brawn et al. (2016) suggested that the increase in dry season length may threaten populations of tropical birds in protected areas, even without a direct loss of habitat. Such evidence, together with the general biogeographic pattern of a decrease in species richness and abundance of woodland bird species towards the SW of the Western Palearctic (Mönkkönen, 1994; Tellería and Santos, 1994), suggest that the Gran Canaria blue chaffinch is a 'woodland survivor' stranded in a suboptimal habitat, in the eastern limit of the Canary forests of any kind. The South hills crossbill (*Loxia sinesciuris* of the *curvirostra* complex), inhabiting only the higher elevations of two small mountain ranges in southern Idaho (Rocky Mountains, USA), poses a similar case of a declining habitat specialist of coniferous forests (Benkman, 2016), where hot events (i.e., more than four hot days > 32 °C per year) recorded from 2003 to 2011 caused a 20 % annual decline, with a total decline of 80 % of the population.

Since one year after the forest fire of July 2007, the blue chaffinch population of Inagua has shown a steady growth until 2016, with an average annual increase of 23.7 %, a figure that is around the upper boundary of other threatened species (Green and Hirons, 1991; Butchart et al., 2006). This increase occurred with minor implementation of conservation actions (these limited to providing water supplies; Pascual Calabuig, pers. com.), leaving the species to its fate and dependent on the natural recovery of the pine forest. Moreover, 15 blue chaffinch juveniles were translocated from Inagua to La Cumbre pinewood forest, 2–4 km away, at the end of the summer 2015 (nine females and six males; this extraction was the most remarkable carried out in any one year from 1994 to 2016; Felipe Rodriguez and María Dolores Estévez, pers. comm.). In spite of this extraction, the population at Inagua did not show any sign of a population decrease, continuing with its steady increase from 2015 to 2016. The positive population trajectory is typical of species living at low densities that often recover after the perturbation that decreased their numbers ceases. This phenomenon is the result of high fidelity to good habitat patches, reduced mortality and increased fecundity and reproductive rate (e.g., Ferrer et al., 2013; Krüger et al., 2010; Le Corre et al., 2015; Smith et al., 2015). The case of the Gran Canaria blue chaffinch is one of those rare examples of how an endangered species recovers from a demographic crisis in the absence of human interventions, when the mere protection of the habitat is sufficient [see also Impey et al. (2002) for the Rodrigues fody, *Foudia flavicans*; Groombridge et al. (2009) for the Seychelles kestrel, *Falco araea*; Brooke et al. (2012) for the Raso lark, *Alauda razae*, confined to the 7 km^2 island Raso, Cape Verde; Guevara et al. (2016) for *Podiceps juninensis* in northern Andes; Burt et al. (2016) for *Copsychus sechellarum* in the Seychelles].

In conclusion, the Gran Canaria blue chaffinch is a small passerine of the Western Palearctic that attains the lowest population densities for a forest bird, even in the most favourable woodland areas (ca. 10 birds/km^2). However, the population has remained relatively stable during the last twenty–three years. The creation of the Inagua strict reserve and its role as a special protection area for birds was not followed by a population increase and did not protect the species from the demographic crisis associated with a devastating wildfire that halved its population, although the strict protection status of Inagua allowed for a quick recovery of the species. The species showed high resilience and adaptation to wildfires, recovering at a fast rate (24 % average yearly increase) in the following eight years, without human intervention. These results clearly illustrate that an insular endemic species with a population size below the 'average' minimum viable population level may have stable numbers during relatively long periods without becoming extinct in spite of being recognized as endangered (Martín, 2009).

Acknowledgements

The study was supported by the Conservation Program for the blue chaffinch implemented by the Gobierno de Canarias (1991–2004), Cabildo de Gran Canaria (2005–2015), and was partially funded by the European Union (1995–1996: LIFE94 NAT/E/001159; 1999–2002: LIFE98 NAT/E/005354; 2016: LIFE14 NAT/ES/000077) and a research contract between MNCN/CSIC and GESPLAN, S. A. U. (2008). JS currently works within the Madrid's Government research group network REMEDINAL3–CM (S–2013/MAE–2719). We thank Joachim Hellmich, Pascual Calabuig, Ruth de Oñate and Felipe Rodríguez for their help and company during different phases of this long work, and to Claire Jasinski and Ana Rey for improving the English of the manuscript.

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