



Macaronesian birds and the natural environment of the canary

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Introduction

Macaronesia is a biogeographic region comprising five oceanic archipelagos (Azores, Madeira, Selvagens, Canary Islands and Cabo Verde) with more than 30 principal volcanic islands (i.e. larger than 3 km²) showing a variable degree of erosion, and located in the northeastern Atlantic Ocean (Fig. 1.1). They show many floral and faunal affinities among archipelagos and with the European and African mainland wildlife. The different geographical positions of each archipelago in relation with the mainland (less than 100 km away from the mainland for the Canary Islands and more than 1300 km from the Azores), the huge variation of geological ages (0.035–25.7 million years (my)), altitudes (122–3.718 m above sea level) and latitudes (from 39°N to 15°N) provide a diverse collection of ecological conditions and unique biotas (Florencio et al., 2021).

The Macaronesian habitat diversity includes semiarid shrublands, dunes, coniferous and broadleaved forests, subterranean microecosystems, freshwater lagoons and alpine habitats (Fig. 1.2). Such a variety of ecological conditions, together with the intrinsic geological dynamism of each island, has contributed to the evolution of a rich and stunning terrestrial biota with >23% of species (excluding protozoans, bacteria and virus) being endemic (Illera et al., 2012).

The strong latitudinal gradient of Macaronesia (Fig. 1.1) produces significant climatic gradients too. In general, annual temperatures are negatively associated with latitude, with Cabo Verde being the driest and warmest archipelago, and the Azores being the more humid and colder on average.

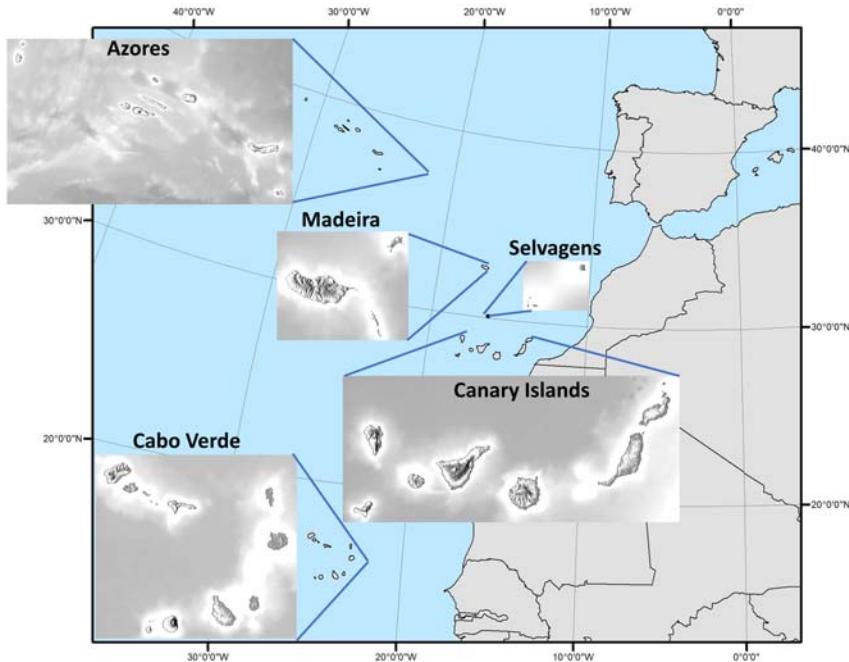


Figure 1.1 Map of Macaronesia with the five oceanic archipelagos from north to south: Azores, Madeira, Selvagens, Canary Islands and Cabo Verde. The island canary (*Serinus canaria*) only occurs on Azores, Madeira and the Canary Islands. *Map elaborated by Juan Carlos Illera.*

([Cropper and Hanna, 2014](#)). The Azores islands show typical temperate climates with no dry summers, except for Santa María and Graciosa islands. Temperatures in the Azores are on average above 14°C during the winters and above 20°C during the summers ([Cropper, 2013](#)). The archipelago of Madeira shows a steep topography on Madeira Island with mountains close to 1900 m above sea level. The climate is considered temperate with mild winters (above 18°C on average) and dry and warm summers (above 24°C), especially, along the coastal areas of Madeira and on Porto Santo and Desertas ([Cropper and Hanna, 2014](#)). The climate in the Canary Islands is considered subtropical, although there is a strong longitudinal gradient with the eastern islands showing a semiarid climate, and the central and western islands with a more temperate climate ([Marzol-Jáén, 1984](#)). In addition, the Canary Islands show an altitudinal gradient reaching extreme temperature contrasts in the alpine habitats. Cabo Verde is the driest and warmest archipelago with a subtropical climate and temperatures above

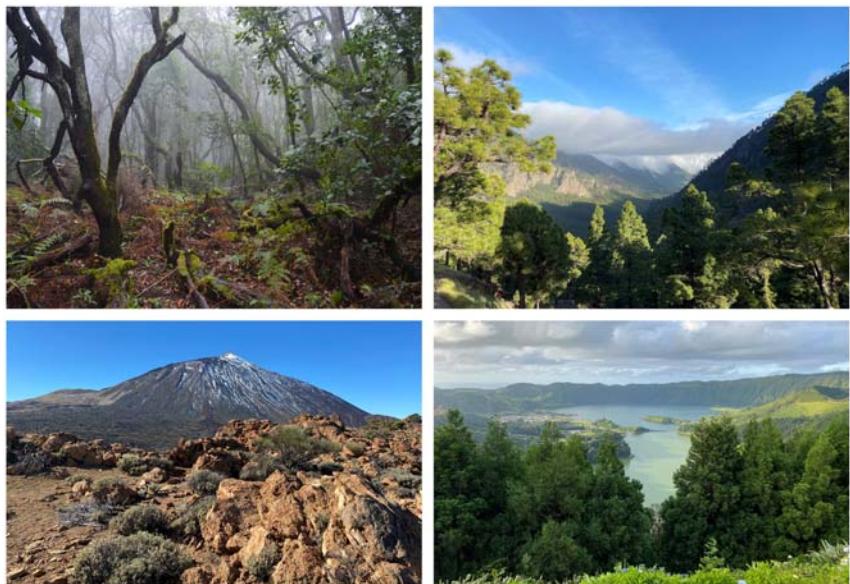


Figure 1.2 The climatic heterogeneity of Macaronesia offers many different habitats from semidesert areas to humid forests. Four types of habitats are shown. From top left to bottom right: Laurel forest (La Gomera), pine forest (La Palma), alpine habitat (El Teide, Tenerife) and freshwater lagoons (São Miguel). *Photos: Juan Carlos Illera.*

20°C and 25°C during the winter and summer, respectively (Fernández-Palacios, 2010; Cropper, 2013).



Origin of the avian species

Genetic and genomic studies of native bird species performed over the last 30 years have shed light on the evolutionary histories and the origin of the Macaronesian avifauna. Regarding the origin, all results published so far conclude that the avifauna only shows close affinities to European and African taxa, thus discarding colonisations by American species. These phylogenetic affinities show strong concordance with the proximity of these archipelagos to the European and African mainland, and the prevailing winds (Illera et al., 2012). Macaronesia is under the influence of the northern trade winds, which blow from the northeast to the southwest areas in the Northern Hemisphere. These winds are

sometimes replaced below 20°N (i.e. just affecting Cabo Verde) by southwesterly monsoonal winds due to the northerly migration of the Intertropical Convergence Zone (Cropper, 2013). The trade winds could explain the recurrent and independent arrival of western Palearctic taxa to the Macaronesian islands (Illera et al., 2012), and the pattern of sequential colonisation from north to south recorded in the region (e.g. Päckert et al., 2006; Illera et al., 2014; Recuerda et al., 2021). Finally, plumes of Saharan dust are common in Macaronesia (Fig. 1.3), although they are more frequent in the closest archipelagos to the African mainland (i.e. the Canary Islands, Selvagens and Madeira) but rare in Azores. These conditions could have favoured the arrival of African taxa to Macaronesia in the past (Illera et al., 2007).

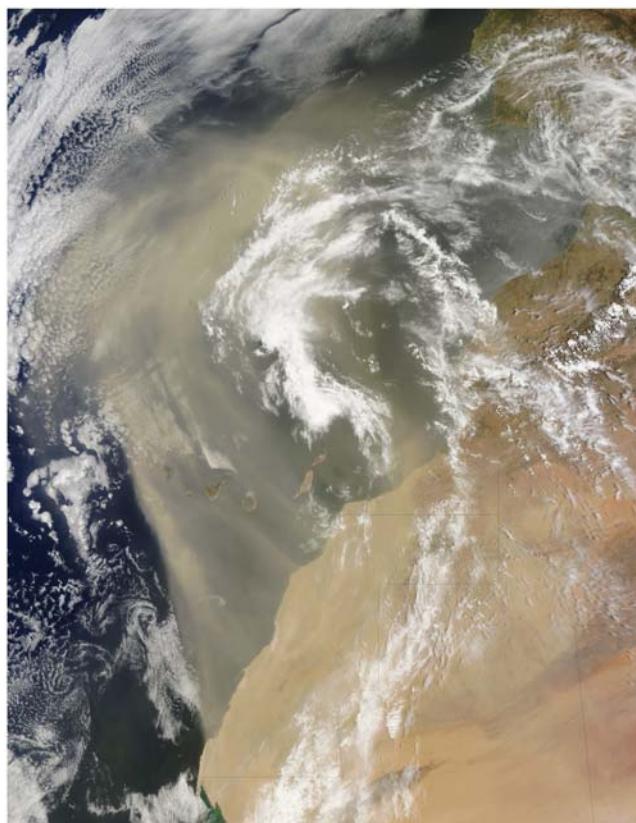
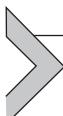


Figure 1.3 Saharan dust over Canary Islands, Selvagens and Madeira in 2012. These Saharan dust clouds provoke the arrival of many avian migrants to Macaronesia. Photo from NASA.



Time of colonisation and extinction

Oceanic islands are considered natural laboratories to study the ecological and evolutionary mechanisms since Darwin's theory of evolution (Emerson, 2002). However, before these changes occur, avian taxa have to arrive and identify the proximate geographic sources from which island species originated have intrigued to evolutionary biologists since a long time ago (Mayr and Diamond, 2001; Thibault and Cibois, 2017; Mikhailov and Zelenkov, 2020). Most of the avian native and endemic taxa have colonised the region during the last 3 my, and there is evidence that no species predate the age of the oldest emerged land (Valente et al., 2017). These findings rule out that paleo-islands (now submerged) provided refuge or served as stepping stones to colonise the emerged islands for the oldest lineages in the region (Illera et al., 2012). However, the recent origin of avian biotas is still striking since some islands are more than 20 my old, and because the arrival of other less-mobile vertebrates such as lizards, geckos and skinks occurred earlier, during Miocene in the Canary Islands (Illera et al., 2012). Could it be the case that some lineages colonised Macaronesia in older times, but they were extinct? To answer this question, we need to look at the fossil record in the region, which has plenty of extinct avian species including raptors, rails, quails, seabirds and passerines (e.g. Alcover et al., 2015; Rando et al., 2010, 2012, 2020). Probably the most striking remains correspond with the eggshells found in several Miocene paleontological sites in Lanzarote (Canary Islands), which show affinities with ostrich (*Strutio* spp.) and aepyornithoid (*Aepyornis* spp.) taxa (Sauer and Rothe, 1972). These findings are difficult to interpret because the Canary Islands have never been connected with the mainland. Disentangling how and from where these giant flightless birds arrived in the Canary Islands emerges as a formidable biogeographical challenge (Mikhailov and Zelenkov, 2020). Aside from these iconic remains, other extinct species developed flightless adaptations *in situ* probably as a consequence of the absence of predators (Alcover et al., 2015; Rando et al., 1999, 2010, 2020). Unfortunately, we do not know when the extinct species colonised Macaronesia due to the idiosyncrasy of the subfossils collected, that is, they lay on the surface of the volcanic caves where chronologies were absent. Molecular markers are the suitable tools to unveil phylogenetic relationships, establish arrival times and study the specific adaptions to live in island ecosystems for the extinct taxa.

However, ancient DNA studies in the region are still in their infancy, being limited to few taxa and small fragments of mitochondrial genes (Ramírez et al., 2010, 2013). The rapid advance of ancient DNA techniques, including next-generation sequencing, will make it possible to extract DNA from subfossil remains and shed light on these issues in the future (e.g. Renom et al., 2021).

Why and when did these extinct species vanish from Macaronesia? Radiocarbon dates obtained of bone collagen on a selection of these species suggest extinction chronologies related with human colonisation events, that is, within the Holocene period (i.e. less than 10,000 years ago; Illera et al., 2012, 2016; Rando et al., 2020). Some of these extinctions recorded in the Canary Islands are attributed to the arrival of aboriginal people coming from North Africa ca. 2000 years ago (Rando and Alcover, 2010; Rando et al., 2014a). However, most of them are related to European colonisation, which started in the 14th century (Rando and Alcover 2008; Rando et al., 2012). In Azores and Madeira, the initial human occupation corresponded to Viking seafaring people, which likely began between 700 and 850 Common Era (Gabriel et al., 2015; Rando et al., 2014b,c; Raposeiro et al., 2021). In parallel to what happened in the Canary Islands, the posterior arrival of Europeans to Madeira, Azores and Cabo Verde caused the most extinction events documented on these archipelagos (Illera et al., 2012; Castilla-Beltrán et al., 2021; Nogué et al., 2021; Rando and Alcover, 2021). Therefore, except for ostrich and aepyornithoid eggshells, for which it seems plausible to suggest an extinction pattern produced by the climatic and environmental changes, the remaining avian extinction events were likely provoked by anthropogenic actions (e.g. hunting, habitat fragmentation and introduction of invasive species), in a similar way that occurred (and it is still ongoing) in other oceanic archipelagos (Wood et al., 2017; Steadman and Franklin, 2020).



Ecology, evolution and biogeography

Macaronesian birds have contributed to improve our understanding of a plethora of ecological and evolutionary topics, for instance, assembly of land bird communities (Triantis et al., 2022), sympatric speciation by allochrony in seabirds (Friesen et al., 2007; Ramos et al., 2016; Rodríguez et al., 2020) and

classic island syndromes such as the ‘island rule’ effect (Benítez-López et al., 2021) and the evolution of flightlessness (Rando et al., 1999; Sayol et al., 2020). Allochrony refers to when populations of a species breed in different temporal windows. This phenomenon can give rise to speciation because it prevents gene flow between populations, favouring their reproductive isolation and genetic differentiation over time. The island rule effect describes an interesting evolutionary pattern characteristic of island ecosystems, whereby large animals in the mainland evolve towards smaller sizes on islands and small animals occurring in the mainland become larger on islands (Van Valen, 1973). Island biogeography has been recently enriched after the publication of two relevant papers where Macaronesian birds were either the core of the study or were included into a global analysis of 41 oceanic archipelagos (Valente et al., 2017, 2020). The results published in both papers supported completely MacArthur and Wilson’s Theory of Island Biogeography (MacArthur and Wilson, 1967). Firstly, Valente et al. (2017) showed that Azores, Madeira, Canary Islands and Cabo Verde archipelagos reached and maintained a dynamic equilibrium of terrestrial avian species over millions of years. In a subsequent article, Valente et al. (2020) analysed 41 oceanic archipelagos worldwide (including Macaronesia) and confirmed that (1) island richness declines with isolation, (2) the extinction rates decline with island area and, interestingly, (3) the speciation rates increase with island area and distance to the mainland.

A central tenet in island biology has been that sedentary avian species that once colonised an island stayed there forever, that is, without performing posterior dispersal events to other islands or the mainland (but see, Bellemain and Ricklefs, 2008). However, recent studies based on molecular markers, direct observations and GSM/GPRS loggers have revealed that some of the terrestrial avian species inhabiting in Macaronesia show dispersal abilities to move between nearby islands and even among archipelagos (Martín and Lorenzo, 2001; Dietzen et al., 2003; Illera et al., 2014; Martín et al., 2020; Alonso et al., 2022). We are yet far from interpreting the causes and consequences of these findings in terms of, for example, population differentiation with gene flow, the foundation of new breeding populations and maintenance or increase of genetic variability in islands. We thus need further empirical studies addressing specific questions on the patterns and mechanisms explaining the avian movements in Macaronesia.

Macaronesian birds have been crucial to understand how extant ecological interactions shape pollination and seed dispersal processes (e.g. Nogales et al., 2001; González-Castro et al., 2012; Fernández de Castro

et al., 2017). Early research on seed dispersal was mostly constrained to studying the primary seed dispersal (i.e. how a single species disperses seeds) and the ecological consequences for the plants involved (e.g. Nogales et al., 2005; Rumeu et al., 2009). But a captivating secondary seed dispersal process has been documented in the Canary Islands (Nogales et al., 1998; Nogales et al., 2007). The secondary seed dispersal is a mechanism in which seeds are moved sequentially by more than one animal species. This phenomenon may result in a double digestion (sequential endozoochory) or just one (Padilla and Nogales, 2009). The ecological consequences for the plant species involved in this process are formidable because plant seeds can be moved over longer distances than primary dispersal does. The striking participation of three vertebrates in the Canary Islands makes this process fascinating. The first phase is performed by the frugivorous endemic lizards (*Gallotia* spp.), who feeds on the fruits of many Canarian plant species. In a second phase, two predatory birds, the southern grey shrike (*Lanius excubitor*) and the common kestrel (*Falco tinnunculus*), feed on lizards producing a second seed digestion. This last digestion was found not to reduce seed germination and viability rates, and produces an effective long-distance seed dispersal of native and endemic plant species in the Canary Islands (Nogales et al., 2007; Padilla et al., 2012).

Ancient ecological relationships are difficult to determine and interpret when extant and extinct species are involved. However, such an exceptional relationship could be inferred among the Canarian finches (Rando et al., 2010), helped by the discovery of an extinct finch species in Tenerife (Canary Islands), the slender-billed greenfinch (*Chloris aurelio*). This now extinct finch species had a beak shape resembling that of the extant common and blue chaffinches in Tenerife, but with an intermediate size. The discovery of this species suggested that ecological character displacement between extant and extinct finches favoured the co-occurrence in sympatry of these three taxa in Tenerife (Rando et al., 2010). Ecological character displacement refers to when co-occurring species diverge evolutionarily on one or more traits of ecological significance, and the presence of additional extinct granivorous finches in other islands with a formidable beak variation suggests that this ecological phenomenon was recurrent in Macaronesia. The extinction of the intermediate form in Tenerife could have fostered a character release for bill size in the extant finches, allowing the evolution of different bill sizes and producing a continuous gradient in beak sizes between the current finches. However,

such a pattern has not been observed, perhaps because the intermediate bill size ecological niche has in the meantime been occupied by the introduced rodents (Rando et al., 2010).



Evolutionary histories and taxonomy

Phylogeographic and phylogenetic studies performed during the last 30 years revealed a broad array of colonisation pathways and diversification processes in the Macaronesian islands. A common characteristic for all native and sedentary avian taxa is that the Macaronesian islands appear to be the end points of colonisation, that is, there is no evidence of reverse colonisation events from the islands to the European or African mainland. This contrasts with other archipelagos, such as the West Indian and Solomon Islands, which were also the sources of colonising species to the continents (Bellemain and Ricklefs, 2008). In the absence of contemporary gene flow from the mainland, it is plausible to expect lower genetic diversity values in the island biotas when compared to their mainland counterparts, and results support such a prediction in Macaronesia (e.g. Illera et al., 2016; Rodrigues et al., 2016; Mori et al., 2017; Kangas et al., 2018). However, other scenarios such as multiple and consecutive colonisation events and the arrival of large flocks of colonisers may provide small increases in genetic diversity, which nonetheless remains lower than in the mainland (Morinha et al., 2020; Andrade et al., 2022). The lower genetic diversity of island populations seems to be a direct consequence of bottlenecks and founder effects experienced after the arrival (Hansson et al., 2014; Spurgin et al., 2014; Van Doren et al., 2017).

Islands are the exceptional places to study speciation mechanisms due to the idiosyncrasy of these systems. The reasons explaining such suitability are well known, and include (1) species distributions are delimited by physical barriers of sea water, (2) despite a high number of endemic species, island species richness is lower than in continental ecosystems, which makes the interpretation of the results easier and (3) the recurrent geological dynamism of oceanic islands provides an ideal scenario to study the adaptation of their biotas to new environments (Emerson, 2002). Two of the most famous oceanic archipelagos, Galápagos and Hawaii, are also iconic examples illustrating avian adaptive radiations (Grant and Grant,

2007). The adaptive radiation is an evolutionary process in which a single ancestor produces new forms (i.e. species) adapted to exploit different ecological niches (for instance, specialisation in feeding on new trophic resources). In contrast, Macaronesia shows a limited number of avian radiations with a modest number of species involved (Table 1.1). In addition, for most of avian radiation in Macaronesia, we do not know if they were adaptive or nonadaptive. In the case of an adaptive radiation, evolutionary divergence and speciation are due to ecological resource partitioning, while in the latter last process, nonadaptive radiation, the formation of new species may be simply a consequence of the reproductive isolation without ecological speciation (Czekanski-Moir and Rundel, 2019).

Phylogeographic work on the region suggests a pattern of recurrent and independent species arrivals (e.g. Dietzen et al., 2003; Rodrigues et al., 2016; Delmore et al., 2020). Interestingly, results on the evolutionary histories of different Macaronesian species have characterised a scenario with heterogeneous patterns, with each species experiencing a different pathway of colonisation and diversification (Illera et al., 2012). Looking at avian radiations in Macaronesia, the most relevant taxa in terms of number of extant species are the Common Chaffinch Complex (*Fringilla* spp.), where three species (an endemic species per archipelago) have been recognised (Recuerda et al., 2021). A similar case could exist for the Canarian blue tits (*Cyanistes teneriffae*), if the populations of the central and western islands (except La Palma) are to be recognised as true species (Sternvander et al., 2015; Illera et al., 2016). The remaining known extant radiation (that of the blue finches) involves only two species (Table 1.1). A different view could emerge if the extinct species of rails (*Rallus* spp.), quails (*Coturnix* spp.) and finches (*Chloris* spp.) recorded in Macaronesia shared a common ancestor, which is unknown so far.

Most of the taxonomic classifications currently in use come from phenotypic differentiation (e.g. variation in morphological, colour pattern and acoustic traits), but we know that many taxa show similar phenotypes despite having experienced long periods of reproductive isolation (e.g. Kvist et al., 2005; Illera et al., 2018; Rodríguez et al., 2020). This cryptic differentiation could be a consequence of a high degree of niche conservatism without ecological speciation. Thus, similar ecological pressures could produce similar responses in different avian taxa. Future studies using integrative approaches are now needed to evaluate the number of true species occurring in Macaronesia (e.g. Sangster et al., 2016). In this sense, the routine use of next-generation genetic sequencing (see

Table 1.1 Avian radiation events in Macaronesia.

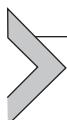
Genus	Species	Islands	Archipelago	References
<i>Fringilla</i>	<i>F. moreletti</i> ²	SM, SMA, SJ, TE, GR, P, F, FL, CO	Azores	Recuerda et al. (2021)
	<i>F. maderensis</i> ²	MD	Madeira	
	<i>F. canariensis</i> ²	TF, GC, LG, LP, EH	Canary Islands	
<i>Fringilla</i>	<i>F. teydea</i> ³	TF	Canary Islands	Rando et al. (2020)
	<i>F. polatzeki</i> ³	GC	Canary Islands	
<i>Coturnix</i> ^a	<i>C. gomerae</i> ^b	LG, TF	Canary Islands	Rando et al. (2020)
	<i>C. lignorum</i> ^b	MD	Madeira	
	<i>C. alabrevis</i> ^b	PS	Madeira	
	<i>C. centensis</i> ^b	SV	Cabo Verde	
	<i>C. spp.?</i> ^b	BG, SMA, GR	Madeira and Cabo Verde	
	<i>C. aurelio</i> ^b	TF	Canary Islands	
<i>Chloris</i> ^{a,b}	<i>C. triasi</i> ^b	LP	Canary Islands	Rando et al. (2010) Alcover and Florit (1987)
	<i>C. sp.</i> ^b	LG	Canary Islands	
	<i>C. spp.?</i> ^b	MD	Madeira	
	<i>P. murina</i>	SM	Azores	
<i>Pyrrhula</i> ^a	<i>P. crassa</i> ^b	GR	Azores	Rando et al. (2017) Stervander et al. (2015)
	<i>C. teneriffae</i> ⁴	TF, LG	Canary Islands	
<i>Cyanistes</i>	<i>C. ombriosus</i> ⁴	EH	Canary Islands	
	<i>C. hedwigae</i> ⁴	GC	Canary Islands	
<i>Rallus</i> ^a	<i>R. loweri</i> ^b	MD	Madeira	Alcover et al. (2015)
	<i>R. adolfocaezaris</i> ^b	PS	Madeira	
	<i>R. montivagorum</i> ^b	P	Azores	
	<i>R. carvaoensis</i> ^b	SM	Azores	
	<i>R. minutus</i> ^b	SJ	Azores	
	<i>O. frutuosoii</i> ^b	SM	Azores	
<i>Otus</i> ^a	<i>O. mauli</i> ^b	MD	Madeira	Rando et al. (2013) Rando et al. (2012)

Superscript corresponds with taxa belonging to the same radiation.

^aTaxa compatible with a radiation, although independent waves of colonisation (i.e. no radiation events) could be plausible too.

^bExtinct species.

Chapter 10) together with the analyses of multiple phenotypic characteristics, such as acoustic, morphological, colour, behavioural and others, should be applied to unravel evolutionary histories (Recuerda et al., 2021; Cumér et al., 2022). The obtained findings will be a key to revise the Macaronesian avian taxonomy, which will offer nature managers an objective tool to develop specific conservation actions (Illera et al., 2016). Finally, different multiomic analyses, such as genomic, epigenomic, transcriptomics and proteomic, seem to be the technologies that will illuminate our understanding on the mechanisms operating in the differentiation and extinction of Macaronesian avian taxa in future years (Leroy et al., 2021).



Distribution, habitat and phylogeography of the island canary

The island canary (*Serinus canaria*) (Fig. 1.4) is a monotypic small passerine (13.5 ± 0.09 g) endemic of three archipelagos (Azores, Madeira and Canary Islands) in Macaronesia (Fig. 1.1). According with previous phylogenetic studies carried out with the true finches, that is, the species belonging to the family Fringillidae, the island canary groups unambiguously with the European serin (*Serinus serinus*) (Arnaiz-Villena et al., 1999; Zuccon et al., 2012; see



Figure 1.4 Male of island canary (*Serinus canaria*) on Tenerife. Photo: Aurelio Martín.

Chapter 4). The European serin is a common species occurring in Europe, North Africa, Near East and, anecdotally, in two Canarian islands: Tenerife and Gran Canaria (Clement, 2020). Their diet includes mainly seeds and pollen and rarely invertebrates (Martín and Lorenzo, 2001; Rodríguez et al., 2015; see also Chapter 2). The species is common in all main islands of these archipelagos, except in Fuerteventura and Lanzarote (Canary Islands) where it occurs in a limited number of $5 \times 5 \text{ km}^2$ grids due to both islands offering few suitable areas (Lorenzo and Barone, 2007; Sepúlveda and Lorenzo, 2020).

The species trend appears to be stable in the three archipelagos. The population size is roughly estimated between 3,000,000 and 5,050,000 individuals in Macaronesia. As there are no significant local extinction events recorded, and the population size estimate is quite large, the species was evaluated as Least Concern (BirdLife International, 2022).

The island canaries inhabit both native and anthropogenic habitats. Within the native ecosystems, they are present along the open habitats, ravines of scrublands (*Euphorbia* sp.), at the edges of thermophilous pine and laurel forests. They are also common in different plantations, such as banana and vineyards, or in urban areas (Carrascal and Palomino, 2005; Palomino and Carrascal, 2005; Carrascal et al., 2008). In addition, they can live in degraded forests with many cleared areas, or in completely deforested islands such as Desertas (Madeira). The altitude gradient is quite broad occurring from the sea level to above 2000 m above sea level (Martín and Lorenzo, 2001).

The movements recorded are mainly produced within islands and outside of the breeding period. However, there are known movements between islands and nearby islets; therefore, occasional dispersal between nearby islands must not be ruled out (Martín and Lorenzo, 2001).

The most plausible colonisation pattern for the island canary in Macaronesia is one wave of colonisation made by the ancestor of the canary from the mainland. The time of colonisation has been recently estimated for the three archipelagos using the cytochrome b mitochondrial gene. According to the available results, the canaries colonised the Canary Islands and/or Madeira first during the late Pleistocene (0.32 my), and the Azores some thousands of years after (0.25 my). However, the broad and overlapping confidence interval on these estimates, as indicated by the lower and upper 95% highest posterior density values (0.12–0.56 my for Madeira/Canary Islands, and 0.10–0.43 my for the Azores), makes it difficult to establish a unique pathway of colonisation (Valente et al., 2017). The phylogeography of the canary has been studied by Dietzen et al.

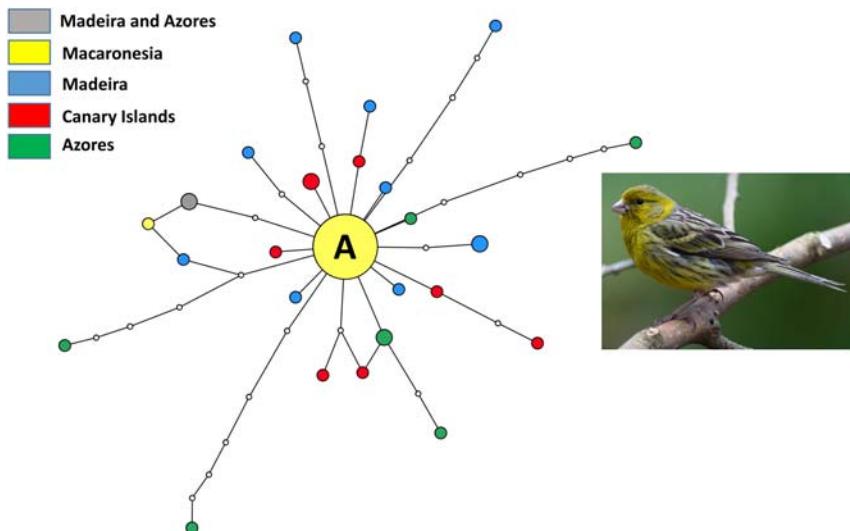


Figure 1.5 Haplotype network of the island canary (*Serinus canaria*) provided by the programme TCS, based on a 974-base-pair fragment of the cytochrome b mitochondrial gene. The sequences used come from Dietzen et al. (2006). Each circle represents one haplotype. The circle sizes show the number of birds that shared each haplotype. The white circles represent the number of mutations needed to change from one haplotype to another. The star-like topology suggests a recent divergence with a limited genetic differentiation among archipelagos. A: Haplotype shared by the three archipelagos. Photo: Aurelio Martín.

(2006) using the same mitochondrial gene (cytochrome b). The sampling included individuals from Pico (Azores), Desertas and Madeira (Madeira) and the main islands in the Canary Islands, except La Palma. Although the sample size was unbalanced and only included one out of the nine islands in the Azores, the results suggested a limited differentiation within and among archipelagos, compatible with a recent range expansion (Dietzen et al., 2006). The most common haplotype (A) was shared for the three archipelagos, providing a star-like topology characteristic of a recent divergence (Fig. 1.5). These authors also analysed some morphological traits: weight, beak size and wing length, but their findings did not reveal a clear morphological differentiation among archipelagos, perhaps, only suggesting slightly local adaptation to some islands (Dietzen et al., 2006). Future studies including a higher and comparable taxon sampling, in combination with high genomic coverage, are now needed to understand the evolutionary history of the island canary in Macaronesia.

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