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Research Article

Introduced population of ring-necked parakeets *Psittacula krameri* in Madeira Island, Portugal – Call for early action

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Abstract

Alien invasive species are major drivers of ecological change worldwide, being especially detrimental in oceanic islands, where they constitute one of the greatest threats to the survival of native species. Ring-necked parakeets *Psittacula krameri* (Scopoli, 1769) are popular pets and individuals escaped from captivity have formed multiple self-sustainable populations outside their native range. For over ten years, free-ranging ring-necked parakeets have regularly been observed in Madeira Island (Portugal) and strong evidence suggests that they have breed multiple times in Funchal, the capital of the island. Herein, we assess the current status of *Psittacula krameri* in Madeira and discuss the possible ecological and economic impacts of established populations of this non-native parakeet. Given the initial stage of the incursion, we advocate for a "rapid response" intervention aimed at preventing the spread of this potential invader.

Key words: invasive alien species, Macaronesia, non-native bird, pest-control, Psittacidae, rapid-response

Introduction

The human driven spread of species outside their native ranges is regarded as a significant threat to biodiversity, especially in vulnerable insular ecosystems where invasive mammalian predators are particularly harmful (Didham et al. 2005; Doherty et al. 2016). Exotic psittacids are one of the most frequently introduced bird groups, with several species known to have successfully established new populations outside their native ranges, often with adverse ecological and economic consequences (Blackburn et al. 2009; Runde et al. 2007). The magnitude of such consequences is still poorly understood (Strubbe et al. 2011; Menchetti and Mori 2014), but negative impacts on indigenous species (e.g. *via* competition), agriculture and human structures have led several species of exotic parrots to be classified as priority taxa for preventive and control measures (Kumschick and Nentwig 2010).

The ring-necked (also rose-ringed) parakeet *Psittacula krameri* is a highly gregarious bird native to sub-Saharan Africa and much of southern Asia (Cramp 1998). It is a medium-sized (40 cm, total body length including the tail feathers) predominantly green parrot with a large red bill, and a very long graduated tail (14.0–28.4 cm) that accounts for more than half of the bird's total length (Butler and Gosler 2004). The species is sexually dimorphic with only adult males presenting a black and pink neck-ring but juvenile males cannot be easily differentiated from adult or juvenile females (Juniper and Parr 1998; Butler 2003). The species nests mainly in tree-holes but is also known to use other natural and artificial cavities (Khan et al. 2004; Butler 2003). In the native range, the breeding season spans from January to June and a typical clutch has three to four eggs (Cramp 1998). Ring-necked parakeets can travel more than 6 km per day (Butler 2003) and introduced populations in Hawaii (Kauai Island) had an average home range of 1,771 ha (0.11–6437 ha; n = 16) (Avery and Shiels 2017).

Ring-necked parakeets have a broad environmental niche (Strubbe and Matthysen 2009a) and, in its native range, the species can be found from sea level up to 2,000 m above sea level in a wide variety of habitats, ranging from mangroves, savannas and moist forests, to open farmland and even urban parks and gardens (Cramp 1998; Ivanova and Symes 2019). This flexibility, along with a large clutch size, a suspected high juvenile and adult survival, generalist foraging behaviour and its great popularity as pet, has allowed this species to become the most widely distributed parrot in the world, with naturalized populations in at least 40 countries on four continents (Butler 2003, 2005; Mori et al. 2013; Jackson et al. 2015). In Europe for instance, the species is established in at least ten countries, with over 90 breeding populations and an estimated 85,000 feral individuals as of 2015 (Pârâu et al. 2016). Introduced populations of ring-necked parakeet may take up to several decades to become established, but once they succeed, they can increase rapidly and cause serious problems to both native wildlife and humans (reviewed by Menchetti et al. 2016 and White et al. 2019).

The first record of an escaped ring-necked parakeet in mainland Portugal dates to the late 1970s, when a single individual was observed at the Tagus estuary (Matias 2002). By the late 1980s, a small naturalized population was already established in Lisbon (Catry et al. 2010). In 2002, the expanding population was estimated to consist of over 250 individuals (Matias 2002), mostly concentrated in Lisbon and Mira regions, but with scattered observations in many other localities throughout the country (Equipa Atlas 2008). In July 2015, the species' main roost in Lisbon was estimated to be composed of up to 644 birds, suggesting the parakeet's population in the capital city of this country is rapidly and exponentially increasing (Luna et al. 2016).

In Macaronesia (biogeographical region comprising Azores, Madeira, Canaries and Cape Verde), the species has been established for several

years in the Canary archipelago (Carrascal et al. 2008) and observations of escaped individuals have been reported in Azores (Equipa Atlas 2008). In Madeira Island (Portugal), escaped individuals have been observed for more than a decade (R. Rocha *pers. obs.*) and, in the most recent checklist update of the birds of the Madeira and Selvagens archipelagos, the species has been reported as being seen frequently in the island's capital, Funchal (Romano et al. 2010). Here, we aim to (1) describe the incursion of ring-necked parakeets in Madeira Island, (2) discuss the ecological and economic impacts that can arise from this introduction and (3) advocate for a precautionary approach to this potential threat.

Materials and methods

Since the late 1990s, reports of ring-necked parakeets appeared in several unpublished trip reports and other online sources (e.g. Matias 2010), leading to increased suspicions that the species might already be expanding in Madeira. Most observations of free ranging ring-necked parakeets in Madeira were centred on the area surrounding Santa Catarina urban park (one of Funchal's main urban green areas; 32°38′43″N; 16°54′51″W) and regarded a single bird. However, in mid-2009 flocks of up to six individuals were observed on several occasions (R. Rocha *pers. obs.*), across multiple locations in the city. Based on this, over ten non-systematic survey visits (of *ca.* one to two hours) were conducted in 2009–2011, during the suspected breeding season of the species (likely to take place between February and June) to the main urban parks in the areas surrounding sites of known observations of ring-necked parakeets. These visits led to over a dozen direct observations and in 2014, twenty of the green areas in Funchal were selected for systematic monitoring. Selected green areas included public parks, private gardens, botanic gardens and green spaces surrounding churches and public buildings (Supplementary material Figure S1). These areas were visited once a month between January and December, and a minimum of one observer recorded ring-necked parakeets for 30 minutes one hour before sunset.

Additionally, in September 2019 we prospected the areas where ring-necked parakeets had been observed and searched for additional records on GBIF (www.gbif.org), an international network and research infrastructure including open access data from a wide variety of sources, from museum collections to citizen science platforms, such as eBird (www.ebird.org) or *iNaturalist* (www.inaturalist.org).

Results

Repeated visits to the surroundings of Santa Catarina urban park in late-2009 led to the observation of an adult female using a tree-hole on a barbusano (*Apollonias barbujana* (Cav.) Bornm.) located at Quinta Vigia

Figure 1. Adult female ring-necked parakeet *Psittacula krameri* using a tree-hole on a barbusano *Apollonias barbujana* at Quinta Vigia, Funchal. Photographed on 27 October 2009. Photo by Ricardo Rocha.

Figure 2. Adult male and female ring-necked parakeets *Psittacula krameri* in mating ritual at Quinta Vigia, Funchal. Photographed on 7 February 2011. Photo by Ricardo Rocha.

(32°38′40.78″N; 16°54′55.66″W; Figure S2) (Figure 1). The park's gardeners confirmed that a pair of ring-necked parakeets had started using the tree-hole in 2008, stating that although they had not observed any chicks, they heard calls coming from the tree-hole on several occasions, even when no adult individual was thought to be inside. This, in addition to an apparent sudden increase in the number of birds, may suggest that the species might have already bred in Madeira in 2008. Repeated visits to the same tree-hole in early February 2011 (beginning of the species' breeding season in mainland Portugal (Matias 2002)) confirmed that it was being used again by a pair of ring-necked parakeets, which were observed mating on the periphery of the tree-hole (Figure 2). Breeding was later documented in

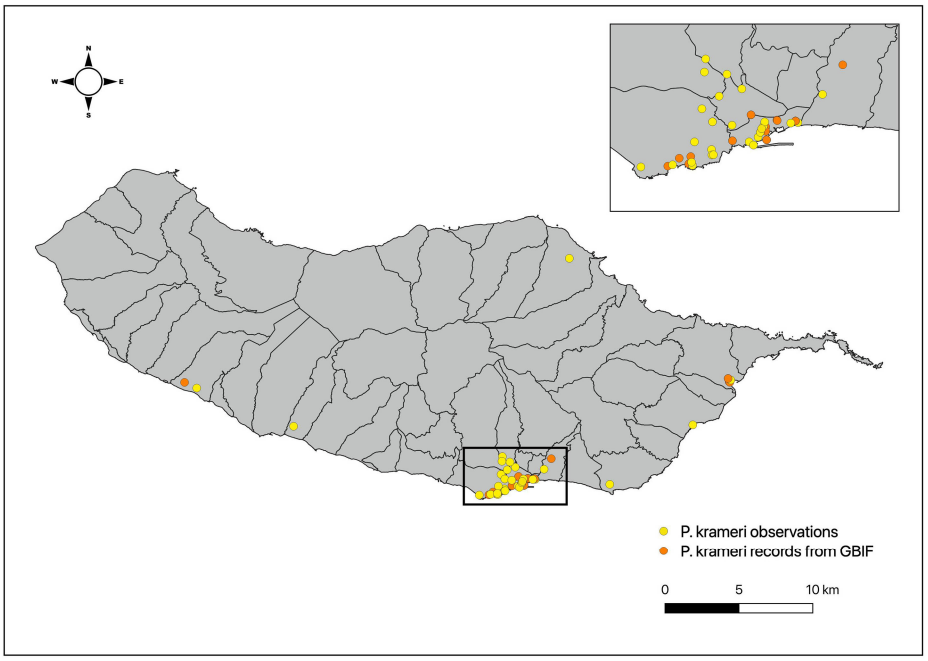

Figure 3. Distribution of the observations of ring-necked parakeets *Psittacula krameri* in Madeira Island between 2001 and 2019. Location of the observations in Funchal (the capital of the island) are shown in the map inset. See Supplementary material Figure S3 for the distribution of observations sub-divided into four-year intervals (2001–2004, 2005–2009, 2010–2014 and 2015–2019). Coordinates and year of observation are provided in Table S1.

Madeira by the Madeira Breeding Bird Atlas team (Equipa Atlas 2013), suggesting that by then, the urban parks of the island's capital might already be home to a small, yet reproducing, population of ring-necked parakeets.

The systematic visits to the 20 green areas in 2014 returned no observations. However, during the monitoring period, flocks of up to four individuals were observed by elements of the monitoring team in multiple areas of the city and an additional nesting site was detected in a *Platanus* sp. tree hole, *ca.* 1.5 km from the previously identified nest (32°38′20″N; 16°55′39″W; Figure S2). This tree hole was still being used by a pair of ring-necked parakeets in 2016, suggesting that breeding was still taking place. No breeding has been detected ever since but individual birds continue to be observed across the city – latest confirmed sighting from July (two birds, observed at 32°38′54″N; 16°55′1.16″W and 32°38′9″N; 16°56′38″W) and December 2019 (two birds, observed at 32°38′54″N; 16°55′1.16″W) (Figure 3 and Table S1).

Discussion

Free-ranging ring-necked parakeets are regularly observed and have probably bred multiple times in Funchal during the last ten years. The current status of the population is unclear, since no indication of breeding has been detected since 2016. However, the island population is not too far from the criteria used to describe a population as established, according to the definition used by Pârâu et al. (2016) (namely, that a population is present for over 10 years, with evidence of breeding persisting until present).

The apparent reduction in the number of observed individuals of ring-necked parakeets since 2014 seems to match a period of potential food scarcity, due to considerable damage caused by invasive red palm weevils *Rhynchophorus ferrugineus* (Olivier, 1790) (Coleoptera: Curculionidae) on Canary Island date palms *Phoenix canariensis* H. Wildpret, 1882, a common ornamental palm in Funchal whose fruits were regularly consumed by ring-necked parakeets in Funchal. The red palm weevil was first detected in Madeira in 2008 and caused massive mortality of palms across the island in the following years. Although it cannot be excluded that the ring-necked parakeets previously observed in Funchal might have moved to different areas of the island, the reduced accessibility to previously abundant palm fruits might have also limited their reproduction. We therefore advocate that the perceived reduction in ring-necked parakeets in Funchal should be seen as a conservation opportunity to eliminate this potential invasive species, through their complete eradication.

Potential impacts of ring-necked parakeets in Madeira

Ring-necked parakeets are highly successful in adapting to new areas, and once established in a new territory are known to expand rapidly (Strubbe and Matthysen 2009b). The species is considered a major agricultural pest throughout its native range (e.g. damage to maize crops in Pakistan has been reported to exceed 50% (Khan et al. 2006)), and they are also proving to cause adverse crop impacts in introduced areas, with severe damages to vineyards in the UK (Juniper and Parr 1998), and reports of depredation on orange *Citrus* × *sinensis* and cherry *Prunus* spp. plantations in mainland Portugal (Catry et al. 2010). Given the economic importance of the referred crops in Madeira Island it can be speculated that, if left uncheck, the ring-necked parakeets might pose considerable economic loss.

In addition to potential conflicts with farmers, ring-necked parakeets may affect the native fauna of Madeira. Throughout their non-native range, the effects of ring-necked parakeets on native vertebrate communities have been found to be varied as they were described to compete with native wildlife in some cases but not in others (Menchetti et al. 2016; Ivanova and Symes 2019). However, ring-necked parakeets have been reported to have negative impacts on native cavity-nesting birds (Strubbe and Matthysen 2009b; Mori et al. 2017) and have displaced Europe's largest bat—the greater noctule (*Nyctalus lasiopterus* (Schreber, 1780))—from tree-holes in southern Spain, often killing the bat in the process (Hernández-Brito et al. 2014, 2018). In Central Italy, a smaller congeneric of the greater noctule, the Leisler's bat (*Nyctalus leisleri* (Kuhl, 1817)) was also reported to be killed by ring-necked parakeets competing for the same tree cavity (Menchetti et al. 2014). The Leisler's bat is one of three bat species found in Madeira (Teixeira and Jesus 2009). The island's population is classified as

an endemic subspecies (*N. l. verrucosus* Bowdich, 1825) and, with a population of less than 1,000 individuals, it is currently classified as critically endangered according to the Portuguese Red Book of Vertebrates (Cabral et al. 2005). Any potential impacts on the archipelago's bats is of conservation concern as island-restricted bats are particularly sensitive to the impact of invasive species and, by being usually inconspicuous and less charismatic, population declines in this group often go unnoticed (Conenna et al. 2017). The bird fauna of Madeira is not particularly rich in cavity-nesters, but one of the species that can potentially be negatively affected through competition for cavities with ring-necked parakeets is the common kestrel *Falco tinnunculus canariensis* (Koenig, 1890) (Scalera et al. 2012), an important predator of non-native rodents.

Ring-necked parakeets are also known to compete with native birds for food (e.g. Peck et al. 2014). In areas where they have been introduced, ring-necked parakeets tend to occupy mostly urban/sub-urban habitats, in which food resources are more available (Strubbe and Matthysen 2009a). Nevertheless, given the abundance of tree-holes on Madeira's mature laurel forest and the species' flexible foraging strategy, the possibility of colonisation of natural forest areas cannot be excluded.

Management and final considerations

For long-lived species, such as the ring-necked parakeets, it can be difficult to clarify if the species is already established or if the observed birds are just escaped individuals simply managing to survive in the wild, and consequently having their number augmented by new escapes. Nonetheless, the existence of several ring-necked parakeets living in wild conditions in Funchal urban parks cannot be ignored, as the future potential ecological and economic impacts can potentially outweigh the positive aesthetical/recreational inputs created by these charismatic birds.

Once a vertebrate is introduced it may experience a "lag period" before it increases exponentially in both population and range size (Crooks 2005), after which both control and eradication can be highly costly if not unfeasible (Jeschke and Strayer 2005). Preventing introductions is always the best option, but once they have occurred, the best management strategy is to act upon their earliest stages (Keller et al. 2007). We therefore advocate that efforts should be made to promptly capture the currently small populations of free-ranging ring-necked parakeets present in Funchal urban parks, and similar attention should be given to any other escaped psittacids, such as feral Senegal parrot *Poicephalus senegalus* (Linnaeus, 1766), which was repeatably observed near Quinta Vigia, Funchal during 2009–2010 (Figure 4).

Rapid removal of introduced species during the early stages of the invasion has been proved effective in preventing the establishment of non-native species (e.g. Hodgkins et al. 2012; Bunbury et al. 2019). Early action

Figure 14. Adult Senegal parrot *Poicephalus senegalus* (indeterminate sex) at Quinta Vigia, Funchal. Photographed on 27 October 2009. Photo by Ricardo Rocha.

circumvents the complications associated with increased population size, broader distribution, wider demographic profile and site familiarization of already established invaders, leading to interventions that are less technical, cheaper and present a higher probability of success (Edelaar and Tella 2012). The potential threats associated with the nowadays small and confined population of ring-necked parakeets in Madeira are not presently evident at this early stage of the incursion. The species can remain at low abundances for a period of years, but if it is allowed to expand unchecked, there is a real danger that, when the impacts are properly understood, the population is too large and well established for removal to be achievable. In the UK for example, a single family group of ring-necked parakeets was first recorded in 1969 in Kent, and by 1999 the species' population was estimated at around 6,000, with approximately 30% yearly increase rates in Greater London (Butler 2003). The country's ring-necked parakeet population was estimated to exceed 29,000 birds in 2012 (Peck 2013), and consequently any control scenarios are currently extremely difficult and expensive.

Several methods are presently available for the control/removal of free-ranging psittacids. These range from egg/chick removal, to poisoning, use of fertility control agents, shooting and trapping (see Klug et al. (2019) for a description and brief overview of the main advantages and disadvantages of each method). Nest destruction and shooting have already been employed by the United States Fish and Wildlife Service in a monk parakeet *Myiopsitta monachus* (Boddaert, 1783) nationwide eradication program. Although eradication was not achieved, monk parakeet numbers were reduced by approximately one-half between 1973 and 1975 (Neidermyer and Hickey 1977). Shooting was also the main method used by authorities to successfully eradicate ring-necked parakeets from on the main

Seychelles island of Mahé, after failed trapping attempts and after capture thought mist-netting proved unfeasible as the birds learnt to avoid the nets (Bunbury et al. 2019). This was the first known successful eradication campaign of ring-necked parakeets and had a total cost of approximately US$ 1 million (548 birds were removed over five years; Klug et al. 2019).

Due to the urban context of the Madeira Island's feral ring-necked parakeets, neither shooting nor poisoning present viable alternatives. Given the small size of the population, we recommend a more practical and ethically acceptable solution, combining egg/chick removal and capture of adult birds. Capture could be undertaken by means of mist-netting in the proximity of roosts and feeding grounds, by using traps specially devised for psittacids or nest-box traps (Bunbury et al. (2019) managed to capture 25 birds with mist-nets in the eradication campaign in Seychelles before the birds learnt to avoid the nets). Although we could not find any reference reporting the successful use of tape lures to improve the capture efficiency of parrot species, ample evidence is available regarding its use for attracting and capturing passerines and seabirds (e.g. Wojczulanis-Jakubas et al. (2016)). As such, we consider that the method should also be tested for ring-necked parakeets, but due care should be taken not to harm non-target species. Veterinarians should be consulted throughout the process and meticulous trials should be undertaken in order to reduce wounding rates and test the efficiency of different types of traps and baits.

Regardless of the methods chosen, if removal of the Madeira Island feral ring-necked parakeets is to be attempted, removal techniques should be the most humane possible. Actions should be linked to an awareness raising campaign about the dangers of escaped/released ring-necked parakeets (and other potential invaders). Importantly, efforts should be taken to enforce the recently approved national legislation on non-indigenous and invasive species (Decree 92/2019; Presidency of the Council of Ministers 2019), which lists ring-necked parakeets as an invasive species to the archipelago, making illegal the commercialisation and possession of any specimens of this species. However, this new legislation can lead to unattended consequences, as owners of ring-necked parakeets in fear of being fined or having their animals confiscated may be tempted to release pet birds into the wild. We thus urge authorities to proceed with care and to duly assess the best strategy to enforce the new legislation so to reduce pre-emptive releases of pet animals.

It might be argued that further research on the population biology of the free ranging population of ring-necked parakeets in Madeira Island is needed in order to produce an evidence base to advise management decisions. However, in accordance with Simberloff (2009) and Edelaar and Tella (2012), we assert that lack of locally obtained biological data regarding a well-known potentially damaging non-native species should not be an excuse for inaction. If left unchecked, the ring-necked parakeets

present in Madeira may cause economic and environmental impacts similar to the ones reported in other areas where the species has been introduced. Hence, we reaffirm that a prudent and quick action taken at this establishment phase is the most effective way to deal with this exotic bird.

As geographic distances are shortened by our globalized societies, an increasing number of species will (intentionally or unintentionally) reach areas previously inaccessible to them (Reino et al. 2017). If we are to prevent the major ecological and economic consequences that might surge from an increasing wave of non-native species introductions, we must be vigilant regarding new arrivals and act to prevent their establishment as soon as they are detected.

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Supplementary material

The following supplementary material is available for this article:

Figure S1. Distribution of 20 count stations used to survey ring-necked parakeets in 2014.
Figure S2. Distribution of suspected breeding sites of ring-necked parakeets in Madeira Island.
Figure S3. Observations of ring-necked parakeets in Madeira Island, sub-divided into four-year intervals.
Table S1. Coordinates, dates and number of ring-necked parakeets observed in Madeira Island between 2001-2019.

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