Chapter 12
Effects of the Recent World Invasion by Ring-Necked Parakeets *Psittacula krameri*

Mattia Menchetti, Emiliano Mori, and Francesco Maria Angelici

Introduction

One of the main components of human-induced global change is represented by the translocation of species from their native ranges to alien environments, where they may exert significant damages (IUCN 2000; Mack et al. 2000; Genovesi and Shine 2004; Wonham 2006). Throughout the history of life on Earth, geographic isolation facilitated the diversification of animal and plant taxa (Sanmartin et al. 2001; Dirzo and Raven 2003). One of the main drivers of evolutionary patterns is given by slow processes of natural dispersal and colonization of new geographic areas. Since the beginning of the Holocene, humans began a voluntary or involuntary transport of species (Vitousek et al. 1997; Hulme 2009; Ellis 2011). The number of these species has increased dramatically over the last 200 years, together with the expansion of the rate of human migration and trade (Mack et al. 2000; Hulme 2009). Three main introduction pathways are currently identified: (1) accidental escapes from captivity, (2) accidental introductions through trade and tourist routes and (3) intentional introductions for hunting, ornamental purposes or individuals released by 'animal rights' groups, and biological control (Pimentel 2002; Hulme 2009).

M. Menchetti (✉)
Department of Biology, University of Florence,
Via Madonna del Piano 6, Sesto Fiorentino (Florence) 50019, Italy
e-mail: mattiamen@gmail.com

E. Mori
Di.S.A.F.A., Entomology and Zoology, University of Turin,
Largo Paolo Braccini, 2, Grugliasco (Turin) 10095, Italy
e-mail: moriemiliano@tiscali.it

F.M. Angelici
Fondazione Italiana per la Zoologia dei Vertebrati (FIZV), Via Cleonia 30,
Scala C, Rome 00152, Italy
e-mail: francescomariaangelici@gmail.com

F.M. Angelici (ed.), *Problematic Wildlife*, DOI 10.1007/978-3-319-22246-2_12

Many species kept as pets, as attractions in urban parks, and for fur farms have escaped from captivity, occasionally establishing self-sustainable populations (Reino and Silva 1996; Duncan et al. 2003). Birds are remarkably recurrent among all introduced animals, with more than 1400 attempts to introduce 400 species recorded worldwide (Lever 1987; Lockwood 1999; Duncan et al. 2003). Among those, parrots are one of the most popular groups because of their colourful plumage and for collecting purposes (Cassey et al. 2004; Menchetti and Mori 2014). It has been estimated that about two-thirds of all parrot species are commonly transported outside their natural range (Cassey et al. 2004; Menchetti and Mori 2014), corresponding to approximately four million parrots per year taken from the wild to sustain the pet market, with an annual industry of 1.4 billion dollars (Drews 2001; Mori et al. 2013a). Moreover, many species are decreasing even inside their natural range because of continuous capture and nest robbing (Drews 2001; Cassey et al. 2004). More than 16 % of living Psittaciformes species (60 out of 335 species) has currently established exotic breeding populations (Menchetti and Mori 2014). Identifying those species that have a higher predisposition to establish themselves in a territory and become invasive (Daehler and Strong 1993; Duncan et al. 2003; Blackburn et al. 2009) is a challenging task. Parrots have all of the features that increase bird establishment success, e.g. wide ecological tolerance, highly synanthropic behaviour, high number of individuals traded (Duncan et al. 2003; Shwartz et al. 2008; Menchetti and Mori 2014). Thus, they often have a high probability of developing self-maintaining populations, even starting from a few released individuals (Cassey et al. 2004).

The Ring-Necked Parakeet *Psittacula krameri*

The ring-necked parakeet *P. krameri* (Fig. 12.1) is a widely distributed gregarious parrot, naturally distributed in tropical Sub-Saharan Africa and in the Indian subcontinent (Fig. 12.2), with four subspecies recognized on morphological and geographical bases (Cramp 1985; Del Hoyo et al. 1997; Juniper and Parr 1998: Fig. 12.2):

- *P. k. krameri*: African ring-necked parakeet. This subspecies is generally pale green, with black chin and continuing black across lower cheek. Collar on hind neck is pinkish. The tail is darker than the rest of the body, with central feathers blue and yellow-green tipped. The upper mandible is red with a black tip; the lower is blackish-red. Black neck and cheeks are not present in the female as well as the collar. Tail feathers are longer in males than in females. It is naturally distributed from Western Africa (Senegal, Guinea, Southern Mauritania) to Uganda and Southern Sudan
- *P. k. parvirostris*: Abyssinian ring-necked parakeet. Head and cheek are less yellowish, and the bill smaller than in the nominate subspecies. The upper mandible is bright red, although less blackish towards the tip with respect to *P. k. krameri*. It is distributed in Southern Sudan, Eritrea, Ethiopia and Djibouti

Fig. 12.1 A male ring-necked parakeet in an urban park in Rome (Italy)

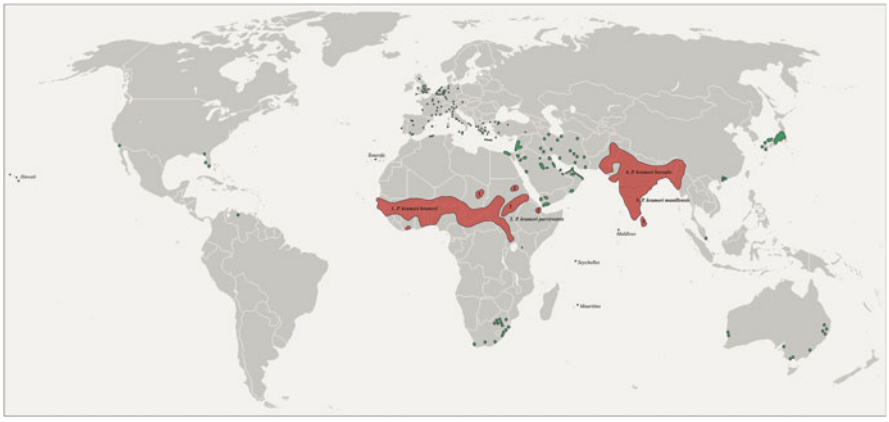

Fig. 12.2 Global distribution of the ring-necked parakeet (Del Hoyo et al. 1997; Juniper and Parr 1998; Latsoudis 2007; DAISIE 2008). In *red*, native range: subspecies are reported. In *green*, introduced range. Distribution of the alien population has been implemented with occurrences from the Alien Parrot Observatory (http://www.inaturalist.org/projects/alien-parrots-observatory)

- *P. k. borealis*: Boreal ring-necked parakeet or Neumann's ring-necked parakeet. This subspecies is larger than *P. k. krameri*, with wholly red upper mandible and black markings on lower mandible. It is naturally present in Pakistan. Northern India, Bangladesh, Nepal and Myanmar
- *P. k. manillensis*: Indian ring-necked parakeet. It is the largest subspecies, slightly paler and yellower than *P. k. borealis*. Its distribution range includes Southern India and Sri Lanka

Fig. 12.3 An adult couple of *P. krameri* in an urban habitat. Male on the *left*, female on the *right*

Psittacula krameri represents the most widely introduced parrot species throughout its native range (Butler 2003; Mori et al. 2013a, b) and is also abundant in its natural range (Cassey et al. 2004).

The general plumage is clear emerald green; the long tail is blue-green, yellow in the ventral part. The beak, large and hook-shaped, is red in colour, although the lower mandible is black in adult males.

This species presents a marked sexual dimorphism: adult males (over 3 years old) have a reddish to black collar surrounding the neck that is missing in both adult females and young (Fig. 12.3). Wing span may reach 40 cm, as well as the total body length including the tail feathers (Del Hoyo et al. 1997; Juniper and Parr 1998). The noisy squawking call of this parrot is unmistakable, although it has a wide vocal repertoire (Del Hoyo et al. 1997). It is currently not known which subspecies has established naturalized populations worldwide, although it seems that individuals in Israel belong to the nominal subspecies, while the populations in other countries belong to *P. k. manillensis* (Del Hoyo et al. 1997; Juniper and Parr 1998; Scalera 2001; BirdLife International 2012). Furthermore, it seems that ring-necked parakeets in the UK probably stem from both *P. k. borealis* and *P. k. manillensis*, based on morphological measurements (Pithon and Dytham 2001).

The ring-necked parakeet may be found in a variety of habitat types, including woodlands, urban parks and cultivated areas surrounded by trees, from 0 to 1600–2000 m a.s.l. It is considered one of the few parrot species successfully adapted to living in anthropic habitats, having withstood the onslaught of urbanization and deforestation. According to this consideration, it may be considered as a habitat-generalist, although it depends on trunk cavities for reproduction (Del Hoyo et al. 1997; Khan et al. 2004). Breeding period is related to the latitude, from November to June in Asia, from August to November in Africa (Del Hoyo et al. 1997; Scalera 2001). In Europe, breeding period is set up in late winter-early spring (Butler et al. 2013). It is a resident, herbivorous parrot, which feeds mainly on buds, fruits, vegetables, blossoms and seeds. In their

native range, ring-necked parakeets may also fly several miles in large flocks to forage in crops and orchards causing damages (Khan et al. 2004; Ahmad et al. 2011). As a matter of fact, the ring-necked parakeet is one of the worst pest species of the Indian subcontinent (Dhindsa and Saini 1994); corn (losses up to 81 %: Reddy 1998a), sorghum (losses up to 74 %: Reddy 1998b) and sunflowers constitute the staple of its diet in summer, fruits in winter (Rao and Shivanarayan 1981; Luft 1994).

Ring-necked parakeets are among the most popular pets with the pet trade luckily keeping the native populations lower, thus limiting damages (Scalera 2001). In its native range, many individuals are still caught from natural environments despite widely practiced breeding in captivity. In Northern India, according to Scalera (2001), up to 5000 ring-necked parakeets are caught per day and sold to wholesale at less than a dollar each. The species is not included in any CITES Appendices, with the only exception being the Ghana population, listed in Appendix III (BirdLife International 2012), although the species in this country cannot be considered as rare (Borrow and Demey 2010).

As a consequence to this wide trade, since the 1970s, escaped individuals have colonized a number of cities in many European (Portugal, Spain, France, Switzerland, Italy, Austria, Germany, Belgium, the Netherlands and Greece), Asian (Turkey, Israel, Syria, Iraq, Iran, Saudi Arabia, Kuwait, Bahrein, Qatar, Oman, Yemen, Maldives, Singapore, Macau, Hong Kong, China and Japan), African (Algeria, Egypt, Kenya, Mauritius, Seychelles and South Africa), North American (USA: California, Florida, Hawaii), South American (Venezuela) and Oceanian (Australia) countries (Del Hoyo et al. 1997; Nebot 1999; Leven and Corlett 2004; Fellous et al. 2005; BirdLife International 2012; Fig. 12.1). No breeding success has yet been recorded in Romania (Liviu Parau, *in litteris*), Poland (Piotr Trijanowski, *in litteris*) and Bulgaria (Boris Nikolov, *in litteris*), although some individuals have been observed in these countries. Physiological tests suggested that the ring-necked parakeet has peculiar seasonal thermoregulatory responses that make it tolerant to low environmental temperatures, allowing it to better cope with a wide range of climatic conditions, and thus explaining its success as an invader species (Thabethe et al. 2013). Such a population increase brought the IUCN to classify this species as least concern (LC) (BirdLife International 2015), and its populations, as well as the extension of natural geographical range, appear to be rising in their native range, both in Africa and in Asia, probably associated with the increase in intensive agricultural crops (Juniper and Parr 1998).

To summarize, the ring-necked parakeet is currently considered the most effective parrot species to colonize new territories where it has been historically absent (Del Hoyo et al. 1997; Menchetti and Mori 2014).

Impacts of the Ring-Necked Parakeet

All introduced species may experience a ‘lag period’ (i.e. up to some decades) after their release (e.g. Zocchi and Panella 1978; Angelici 1986), and then increase exponentially in both range and population size (Keikl 2001). The ring-necked parakeets

took higher latitudes almost by surprise quickly establishing in a high number of areas outside their native range. Such increased amounts of breeding colonies have begun to exert serious problems to native environments, wildlife and humans (Menchetti and Mori 2014, for a review).

Impacts on Native Fauna and Flora

Although the ring-necked parakeet is considered a non-territorial species (Del Hoyo et al. 1997, during the breeding period, it displays aggressive behaviours against other birds which fly in the surrounding of its nests. Noisy and physical intimidations, as well as direct killings, have been observed against raptors (e.g. *Falco tinnunculus*, *Athene noctua*) and corvids (UK: Cramp 1985; France: Dubois 2007; Italy and Algeria: Menchetti and Mori 2014). Flocks of ring-necked parakeets may also mob larger birds (e.g. seagulls, herons: Dubois 2007). Feeding mostly on unripe fruits and seeds, the ring-necked parakeet may take food before other species consume it, thus enhancing competition with native birds (Fletcher and Askew 2007; Lin Neo 2012). Furthermore, the presence of ring-necked parakeet significantly reduced feeding rates of native birds and increased their vigilance (Clergeau and Vergnes 2011; Peck et al. 2014). Trunk cavities are used by a variety of species for nesting and roosting purposes (Newton 1994; Cornelius et al. 2008; Hernández-Brito et al. 2014a), thus eliciting competition between introduced parrots and native hole-nester birds. Parakeets seem not to compete with native woodpeckers (Strubbe et al. 2009; Newson et al. 2011; Orchan et al. 2012), although harassments may be rarely recorded (Keikl 2001). Woodpeckers are primary cavity nesters; it means that they excavate new holes at each reproduction event. By contrast, ring-necked parakeets rely on existing cavities: so they are classified as secondary cavity nesters, as well as tits, nuthatches and doves. Moreover, woodpeckers tend to nest at lower altitudes on trunks with respect to parakeets (Strubbe et al. 2009; Newson et al. 2011; Orchan et al. 2012). Although ring-necked parakeets are advantaged in competition, being early breeders (Cramp 1985), antagonistic behaviours by ring-necked parakeets are displayed against secondary hole-nesters which select cavities larger than those used by parakeets (Fletcher and Askew 2007; Orchan et al. 2012; Hernandez-Brito et al. 2014). In such cases, displacements and/or nest destructions by parakeets were observed in Europe (Cramp 1985; Strubbe and Matthysen 2007; Czajka et al. 2011; Hernandez-Brito et al. 2014), Venezuela (Nebot 1999) and Israel (Shwartz et al. 2008). Displacement behaviour by introduced ring-necked parakeets is particularly noteworthy if exerted against native, threatened parrots in oceanic islands, such as the endemic *Psittacula eques* in Mauritius (Jones 1980), *Coracopsis nigra* in Mahé Island (Fanchette 2012), *Calyptorhynchus latirostris* in Oceania (Chapman 2005) and *Cyanoramphus cooki* in Norfolk Island (Lever 2005). Despite differences in body size necessarily reflecting different cavity preferences (Martin et al. 2004; Fletcher and Askew 2007; Orchan et al. 2012), different diameters of hole-nests do not exclude possible competition with native species (e.g. European

starlings *Sturnus vulgaris*: Braun et al. 2009). An experimental study showed that ring-necked parakeets may also compete with the nuthatch *Sitta europaea* (Strubbe et al. 2009). This native species may choose large cavities, idoneous for breeding parakeets, and then apply mud to reduce their size (Cramp 1985). Newson et al. (2011) claimed that this competition phenomenon disappears when the degree of urbanization is taken into account. Furthermore, despite being secondary cavity nesters, ring-necked parakeets can enlarge smaller tree holes with their strong beaks to better satisfy their needs for nesting purposes. In Israel, cavity enlargement by ring-necked parakeets improves the breeding success of an alien invasive species, the common myna *Acridotheres tristis* (Orchan et al. 2012). Trunk cavities may also provide parakeets with the occasion to outcompete other native species. Gebhardt (1996) claimed that ring-necked parakeets may displace dormice and bats (*Myotis* sp.) from tree-holes and nest-boxes, without providing further details; Haarsma and Van der Graaf (2013) reported a number of anecdotal observations of dead or weakened bats close to trees used by ring-necked parakeets. In Central Italy, an individual of Leisler's bat *Nyctalus leisleri* roosting inside a cavity had been killed by a pair of ring-necked parakeets who tried to build their nest inside the cavity (Menchetti et al. 2014). A similar behaviour has been recorded against honeybees *Apis mellifera* in Germany (Menchetti and Mori 2014). Such behaviours are only rarely observed because they usually happen in high cavities and possibly at the immediate start of the breeding period. As a result, spatial segregation between alien parrots and native species may take place. Populations of the threatened giant noctule bat *Nyctalus lasiopterus* decreased in an urban park in Sevilla in parallel to the increase in the ring-necked parakeet population (Hernández-Brito et al. 2014a). Active displacement by the parakeets is suggested to occur, triggering conservation problems for this rare bat species (Hernández-Brito et al. 2014a). Ring-necked parakeets may harass and push away European squirrels, only rarely touching them. In France, a group of 3–4 ring-necked parakeets was observed once attacking and killing a European red squirrel *Sciurus vulgaris* (Japiot 2005; Menchetti and Mori 2014). Squirrels are listed among the main predators of the chicks of ring-necked parakeets in Europe (Mori et al. 2013b), so these attacks may be related to a nest defence behaviour by the birds (Philippe Clergeau, *in litteris*). As well, direct killings of black rats *Rattus rattus* have been reported by breeding parakeets around nests in Spain (Hernández-Brito et al. 2014b). Experimental evidence is still required to support the hypothesis that ring-necked parakeets reduce the impact of some invasive predators on native fauna. For instance, Shwartz et al. (2008) observed grey squirrels *Sciurus carolinensis* preying on nests of ring-necked parakeets in the UK. Figure 12.4 summarizes the species impacted by introduced ring-necked parakeets (birds, mammals and insects).

The effect on native flora by introduced ring-necked parakeets has been poorly studied. The role of parrots in seed dispersion is still debated (Wunderle 1997; Norconk et al. 1998; Loope et al. 2001), although the involvement of some parrot species in spreading weeds or alien plants in new environments has been hypothesized (see Menchetti and Mori 2014 for a review). Although Tella et al. (in press) suggested that *P. krameri* may act as seed disperser on long distances for many alien

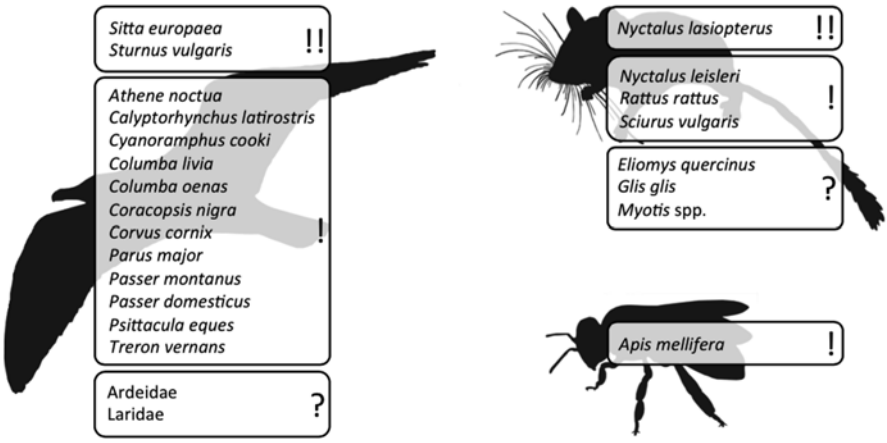

Fig. 12.4 Summary of species impacted by ring-necked parakeet within the introduced range: !!, experimental studies; !, anecdotal observations; ?, suggested impacts

plants, quantitative studies on its seed-dispersal ability in the introduced range are lacking and would be beneficial.

By contrast, droppings by ring-necked parakeet under their roosts may have altered the herbaceous vegetation composition in Southern England, but a direct cause–effect relationship cannot be assessed as no data are available about floral composition before the invasion of parakeets (Fletcher and Askew 2007). Furthermore, defoliation of ornamental trees, resulting in health problems for the plant, may occur (Van Kleunen et al. 2010).

Impacts on Human Activities

In the native range, damages by ring-necked parakeets on crops/orchards, greenhouses as well as on human facilities have been observed. As for the introduced ranges, records are locally significant and increasing in the grey literature (e.g. agriculture bulletins, unpublished technical reports), but damages are rarely quantified (Butler 2003; Bauer and Woog 2008). Orchard damage by ring-necked parakeets has been recorded since the 1950s in the UK (Yealland 1958), and the cost of vineyard damages in Surrey is estimated at about £5000 per year (Fletcher and Askew 2007). In Germany, 10–15 % of apples were damaged in 0.8 ha large orchards, mainly high in the tree (Van Kleunen et al. 2010). On the contrary, crop damages are cited for many European countries, but without any quantification (Spanò and Truffi 1986; Andreotti et al. 2001; Associazione Faunisti Veneti 2004; Vidal Rodriguez 2004; Dubois 2007). Orchards and cultivated fields (corn, vine, *Hordeum* spp., *Pisum sativum*, *Pistacia vera*: Borgo et al. 2005; Latsoudis 2007; Tayleur 2010) are often selected as feeding sites, even when other plants are present within the same

study area (Fletcher and Askew 2007). Barns may also be invaded and grain bags torn by the ring-necked parakeets (Andreotti et al. 2001). While most ring-necked parakeet colonies located in the surroundings of airports never cause problems (e.g. Montemaggiori 1998), three birdstrikes involved this parakeet species in Heathrow Airport (England) from 2004 to 2005, with an average cost of ca. £20,000 each (Fletcher and Askew 2007).

Health Impacts

Parakeets are reservoirs of a plethora of bacterial and viral diseases (Fletcher and Askew 2007; Menchetti and Mori 2014). Thus, free-ranging alien populations may threaten the fitness of native wild species, as well as aviculture and human health. Diseases are transmitted by direct contact with infected birds (handling of plumage and tissues), contaminated equipment, droppings and aerosols of the secretions through nostrils, mouth and eyes. Ring-necked parakeets are known reservoirs of chlamydiosis and other diseases (Menchetti and Mori 2014). Psittacine beak and feather disease was detected in two wild ring-necked parakeets in England through PCR and histopathological examination of affected skin, and this disease could pose a threat to wild birds and captive psittacines (Sa et al. 2014). In 1997–1998, the influenza virus H9N2 was isolated from the respiratory organs of two ring-necked parakeets imported from Pakistan to Japan (Mase et al. 2001). Diseases carried by the ring-necked parakeet may harm the indigenous Vasa parrot *Coracopsis nigra* in Mahé Island (Seychelles: Fanchette 2012). Roost sites of ring-necked parakeet can cause noise pollution (Van Kleunen et al. 2010).

Positive or Neutral Impacts/Interactions

Enlargement of cavities by ring-necked parakeets seems to increase the breeding chances of native species, e.g. *Columba oenas* (Czajka et al. 2011). The general attitude of the public towards ring-necked parakeets is positive. Most people find that parakeets bring colour to urban environments or enjoy observing them flying in the sky (Menchetti and Mori 2014).

Neutral to positive interactions were observed with some coexisting species, e.g. the Alexandrine parakeet *Psittacula eupatria* (Khalegizadeh 2004; Van Kleunen et al. 2010; Weiserbs 2010; Angelici and Fiorillo in press). The few feral individuals of *P. eupatria* in Rome (Italy) are living almost constantly with the most numerous *P. krameri*, forming heterospecific flocks (Angelici and Fiorillo in press). A similar form of apparent mutualism has been observed between *P. krameri* and the Barraband's parakeet *Polytelis swainsonii* in Southern Tuscany (Central Italy). Interactions with other introduced parrot species, e.g. the monk parakeet, were never recorded: even where in syntopy, *P. krameri* and *M. monachus* seem to be

mutually exclusive and never observed in heterospecific flocks or in the same micro-areas (Alessandro Fiorillo, *in verbis*).

Eradication and Numerical Control

Eradication and numerical control of alien/invasive species are always expensive procedures. Furthermore, lethal control against feral/escaped pets is unpopular and may result in public protests (Menchetti and Mori 2014), mainly if these operations regard charismatic species. In detail, common people enjoy the sight of bright parrots flying in courtyards or urban parks (Lever 1987; Polkanov and Greene 2000; Van Kleunen et al. 2010). Thus, eradication programmes against alien Psittaciformes have been started and interrupted several times in North America and the Oceanic islands, such that populations rapidly grew (Lever 1987; Van Bael and Pruett-Jones 1996). In the native range, the use of ultrasonic sound players seems to be an effective way to reduce crop damages and economic losses (Khan et al. 2013). Application of chemosterilants to reduce fitness has been considered, but no data on the effectiveness of this technique is available yet (Lambert et al. 2009). Strategies to prevent new escapes and establishments of self-maintaining populations should also include public education and breeding controls in aviaries (cf. Chapman 2005). From a feasibility point of view, eradication of small populations is still possible, but requires logistically and economically intense efforts. Strict controls are necessary to prevent future invasions and monitoring population increases within adaptive management programmes is more highly recommended (Genovesi and Shine 2004).

Conclusions

According to scientific and grey literature, the ring-necked parakeet appears to be a species characterized by a high ecological success, currently undergoing a range expansion both in its native range and in many areas of the world (Juniper and Parr 1998), where it has been voluntarily introduced or escaped from captivity (BirdLife International 2012). This is possible due to the plasticity of this parrot species, within increase its natural range favoured by anthropization, habitat alteration, an increase of intensive agriculture (Juniper and Parr 1998) and perhaps by climate change, tending towards a gradual increase in mean global temperatures (cf. Huntley et al. 2006).

Acknowledgements Authors would like to thank Philippe Clergeau, Boris Nikolov, Liviu Parau and Piotr Trijanowski for the precious information provided. Dylan Beal revised the first draft of this manuscript and improved English. Alessandro Fiorillo has kindly provided new information and some of his original photographs (Figs. 12.1, and 12.3). Sabrina Kumschick and Diederik Strubbe kindly provided useful comments and improvements on the manuscript.

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