



**Manchester  
Metropolitan  
University**

---

Souviron-Priego, L, Muñoz, A-R, Olivero, J, Vargas, JM and Fa, John (2018)  
The legal international wildlife trade favours invasive species establishment:  
the Monk and Ring-necked parakeets in Spain. *Ardeola*, 65 (2). pp. 233-246.  
ISSN 0570-7358

---

**Downloaded from:** <https://e-space.mmu.ac.uk/620219/>

**Version:** Accepted Version

**Publisher:** Sociedad Espanola de Ornitologia

**DOI:** <https://doi.org/10.13157/arla.65.2.2018.ra3>

Please cite the published version

<https://e-space.mmu.ac.uk>

# THE LEGAL INTERNATIONAL WILDLIFE TRADE FAVOURS INVASIVE SPECIES ESTABLISHMENT: THE MONK AND RING-NECKED PARAKEETS IN SPAIN

## EL COMERCIO INTERNACIONAL DE FAUNA LEGALIZADO FAVORECE EL ESTABLECIMIENTO DE ESPECIES INVASORAS: LAS COTORRAS ARGENTINA Y DE KRAMER EN ESPAÑA

Lucrecia SOUVIRON-PRIEGO<sup>1</sup>, Antonio Román MUÑOZ<sup>1,2</sup> \*, Jesús OLIVERO<sup>1</sup>,  
J. Mario VARGAS<sup>1</sup> and John E. FA<sup>3</sup>

**SUMMARY.**—The international wildlife trade is a lucrative business. Although a huge variety of animal groups are trafficked, the Psittaciformes (parrots) are amongst the most traded avian groups. Deliberate or accidental releases of imported parrots have led to the establishment of feral populations in many countries. Far from their native habitats, parrots may cause economic and ecological damage, and may even favour the transmission of zoonotic diseases. Despite this, the links between numbers of imported individuals and the establishment of non-native populations is not well known. In this study, we analysed data on imports of two well-known invasive parrots, the Monk Parakeet *Myiopsita monachus* and the Ring-necked Parakeet *Psittacula krameri*, in Spain. We contrasted this information with the growth of known naturalised populations of these species from 1975 to 2015 and compared the success of these two species with other Psittaciformes imported in similar numbers into the country. We show that more than 190,000 Monk Parakeets were imported from Uruguay and Argentina, and almost 63,000 Ring-necked Parakeets were legally brought into the country from Pakistan and Senegal. For both species, wild populations grew exponentially following peak importation periods in 2015 (18,980-21,455 monk parakeets and 3,005-3,115 ring-neck parakeets). Even though imports of the two species were banned in Spain in 2005, wild populations are now self-sustaining. We argue that these parrot populations started from accidental and deliberate bird escapes, especially from birds originally captured in the wild. Although lack of more precise data makes it difficult for us to propose clear statistical associations between imports and established bird populations, we nonetheless suggest that the international trade is with some certainty the main cause for the origin of naturalised populations of invasive species in Spain. Our conclusions are useful to help manage similar animal groups that are numerous in the wildlife trade, especially for wild-caught social species.—Lucrecia Souviron-Priego, Antonio Román Muñoz, Jesús Olivero, J. Mario Vargas &

---

<sup>1</sup> Grupo de Biogeografía, Diversidad y Conservación, Departamento de Biología Animal, Universidad de Málaga, Málaga, Spain.

<sup>2</sup> Departamento de Botánica, Facultad de Farmacia, Universidad de Valencia, Avda. Vicente Andrés Estellés s/n, Burjassot, Valencia, Spain.

<sup>3</sup> Division of Biology and Conservation Ecology, School of Science and the Environment, Manchester Metropolitan University, Manchester M1 6BH, UK.

\* Corresponding author: roman@uma.es

John E. Fa. (2018). The legal international wildlife trade favours invasive species establishment: the monk and ring-necked parakeets in Spain. *Ardeola*, 65: 233-246.

*Key words:* biological invasions, CITES, *Myiopsitta monachus*, pet trade, *Psittacula krameri*.

RESUMEN.—El comercio de fauna es un negocio muy lucrativo a nivel internacional, siendo el orden de los Psittaciformes uno de los más traficados dentro del grupo de las aves. Las sueltas directas o indirectas de estos animales han permitido el establecimiento de poblaciones asilvestradas en numerosos países, lejos de sus hábitats de origen, donde estas aves pueden ocasionar daños ecológicos, económicos y favorecer la transmisión de enfermedades zoonóticas. Pese a ello, la relación entre el número de individuos importados y el crecimiento de las poblaciones salvajes en zonas no nativas no se ha estudiado en profundidad. En esta investigación analizamos los datos de las importaciones en España de dos especies invasoras muy conocidas: la cotorra argentina *Myiopsitta monachus* y la cotorra de Kramer *Psittacula krameri*, y contrastamos esta información con el crecimiento de las poblaciones naturalizadas entre 1975 y 2015, además de comparar el éxito de estas dos especies con otras especies de Psittaciformes que fueron importadas en números similares. Encontramos que más de 190.000 cotorras argentinas y casi 63.000 cotorras de Kramer fueron legalmente importadas en España. Argentina y Uruguay fueron los principales países exportadores para la cotorra argentina y Pakistán y Senegal para la cotorra de Kramer. Las poblaciones asilvestradas crecieron exponencialmente tras el pico de importación de ambas especies, alcanzando las mayores cifras en 2015 (18.980-21.455 cotorras argentinas y 3.005-3.115 cotorras de Kramer). A pesar de que las importaciones se prohibieron en 2005, las poblaciones naturalizadas continúan creciendo exponencialmente debido a que actualmente son autosostenibles. Sugerimos que estas poblaciones empezaron por liberaciones accidentales y deliberadas, especialmente de individuos de origen salvaje y no procedentes de la cría en cautividad. Aunque la escasez de datos nos dificultó el poder realizar asociaciones claras estadísticamente entre las importaciones y las poblaciones establecidas, concluimos que el comercio internacional es con certeza la principal causa del origen de las dos cotorras en España. Nuestras conclusiones son útiles para ayudar a gestionar grupos similares que son diana en el comercio de fauna, especialmente para especies sociales capturadas en el medio silvestre. —Lucrecia Souviron-Priego, Antonio Román Muñoz, Jesús Olivero, J. Mario Vargas & John E. Fa. (2018). El comercio internacional de fauna legalizado favorece el establecimiento de especies invasoras: las cotorras argentina y de Kramer en España. *Ardeola*, 65: 233-246.

*Palabras clave:* invasiones biológicas, CITES, *Myiopsitta monachus*, mascotismo, *Psittacula krameri*.

## INTRODUCTION

Humans have kept animals as pets since ancient times (Hughes, 2003), an activity that has persisted in all societies throughout history (Williams, 1956; Ucko & Dimbleby, 1969, Driscoll & Macdonald, 2010). In the last century, a rise in the pet trade and in the use of wildlife products, illegal and legal, has dramatically boosted animal movements across frontiers (Oldfield, 2003). Such trade, if uncontrolled, can directly threaten biodiversity (Rosen & Smith, 2010; Phelps *et al.*, 2016), may cause the spread of zoonotic diseases (Smith *et al.*, 2012; Mazza *et al.*,

2014) as well as open the gateway for biological invasions (Reino *et al.*, 2017).

Populations of numerous vertebrate taxa from fish to mammals are legally caught alive from the wild and are sold as exotic pets or for exhibition (Kisling, 2000; Natusch & Lyons, 2012; Bush *et al.*, 2014). Birds, most often traded for pets, are also among the most successful invaders; many species becoming naturalised in many countries in which they can cause extensive damage to agriculture and natural environments (Hulme *et al.*, 2009; Simberloff, 2014; Turbè *et al.*, 2017). Parrots (Psittaciformes), one of the most popular birds to be traded for pets, are known to success-

fully become established in new environments as a result of accidental escapes or deliberate releases (Abellán *et al.*, 2017; Cardador *et al.*, 2017; Mori *et al.*, 2017).

In the last decade, almost 63% of all known parrot species have been imported into Spain, especially for pets (BirdLife International, 2016; CITES, 2016). This group, together with ducks and geese (Anseriformes) and perching birds (Passeriformes), are the most traded bird orders in the Iberian Peninsula (Abellán *et al.*, 2016). Among the imported parrot species, the Monk Parakeet *Myiopsitta monachus* and the Ring-necked Parakeet *Psittacula krameri* have become rapidly naturalised across the country and beyond (Cardador *et al.*, 2016; Molina *et al.*, 2016; Somoza *et al.*, 2017). It has been demonstrated that these feral populations negatively affect native wildlife, including other avian species (Yosef *et al.*, 2016) and mammals (Hernández-Brito *et al.*, 2014).

In this study, we examined the trends in the number of individuals of the Monk Parakeet and the Ring-necked Parakeet, which entered Spain legally. We compared the growth in this trade with the known establishment and increase of feral populations in the country. In particular, we addressed the following questions: (i) What is the volume of parakeets imported over time? (ii) Where did these individual animals originate and what was the purpose of their import? (iii) How have feral populations evolved in the study period regarding the number of imported individuals? (iv) How have regulatory changes modified the evolution of imports in the study period? and (v) How can our observations for these species help us manage other potential invasive taxa?

## METHODS

### *Study species*

The Monk and Ring-necked Parakeets, native to South America and Central Africa-Asia respectively, have been popular pets

since before the 1970s (Bull, 1973). Millions of individuals of these two species have been captured and bred for export worldwide, and introduced into different parts of the world (Muñoz & Real, 2006; Russello *et al.*, 2008; Strubbe & Matthysen, 2009a; Pârâu *et al.*, 2016; Postigo *et al.*, 2016). Both species share a powerful and unpleasant yell, which is often the reason why many owners may have released birds (Muñoz & Real, 2006, Strubbe & Matthysen, 2009a).

Feral populations of these two species are known to pose threats to a country's economy (Davis, 1974; Avery *et al.*, 2002; Stafford, 2003; Tala *et al.*, 2005) and biodiversity (Strubbe & Matthysen, 2007; 2009b; Czajka, 2011; Hernández-Brito *et al.*, 2014; Menchetti & Mori, 2014; Menchetti *et al.*, 2014; Peck *et al.*, 2014). The Ring-necked Parakeet, in particular, is amongst the top 100 most problematic alien species in Europe (DAISIE, 2009).

The first record of a free-living Monk Parakeet in Spain dates back to 1975, when two individuals were seen in Barcelona and Murcia urban areas (Molina *et al.*, 2016). Evidence of the presence of feral Ring-necked Parakeets is even earlier: a specimen was hunted in Cáceres province in 1970 (Pérez-Chiscano, 1971). Since then, both species have expanded their range throughout Spain, especially in and around large cities (Batllori & Nos, 1985; De Juana, 1985, 1989; Sol *et al.*, 1997; Muñoz & Real, 2006; Somoza *et al.*, 2017) and have the potential for spreading even more widely (Real *et al.*, 2008; Muñoz *et al.*, 2017).

### *Data collection*

We consulted the trade database from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to obtain data on the number of Psittaciformes legally imported into Spain

during 1975-2015. The use and treatment of the data followed the guidelines set in CITES (2013). Three types of import/export data can be found in the CITES (2016) database: comparative tabulation reports, gross reports and net reports. We used data in the comparative tabulation reports because they provide information on origin, source and purpose of imported animals. We examined the total annual number of reported monk and ring-necked parakeets in Spain, their origin, whether they were wild caught or bred in captivity, and the reason for the importation. Data suspected to be duplicate according to CITES guidelines (2013) were removed. CITES trade database only considers data at the country level, which pre-

cludes further analysis on smaller territorial units.

We also gathered information on known population numbers for both species in the wild. Three population estimates were obtained from the literature for 1997, 2002, and 2015. Data for 1997 and 2002 were compiled from information contained in the *Ornithological News* published by SEO/BirdLife in the scientific journal *Ardeola* and published atlases of breeding birds in Spain (Purroy, 1997; Martí & del Moral, 2003), as well as from local bird reports. For 2015, we used data from the latest wild population standardized national censuses carried out in 2015 (Molina *et al.*, 2016; Somoza *et al.*, 2017).

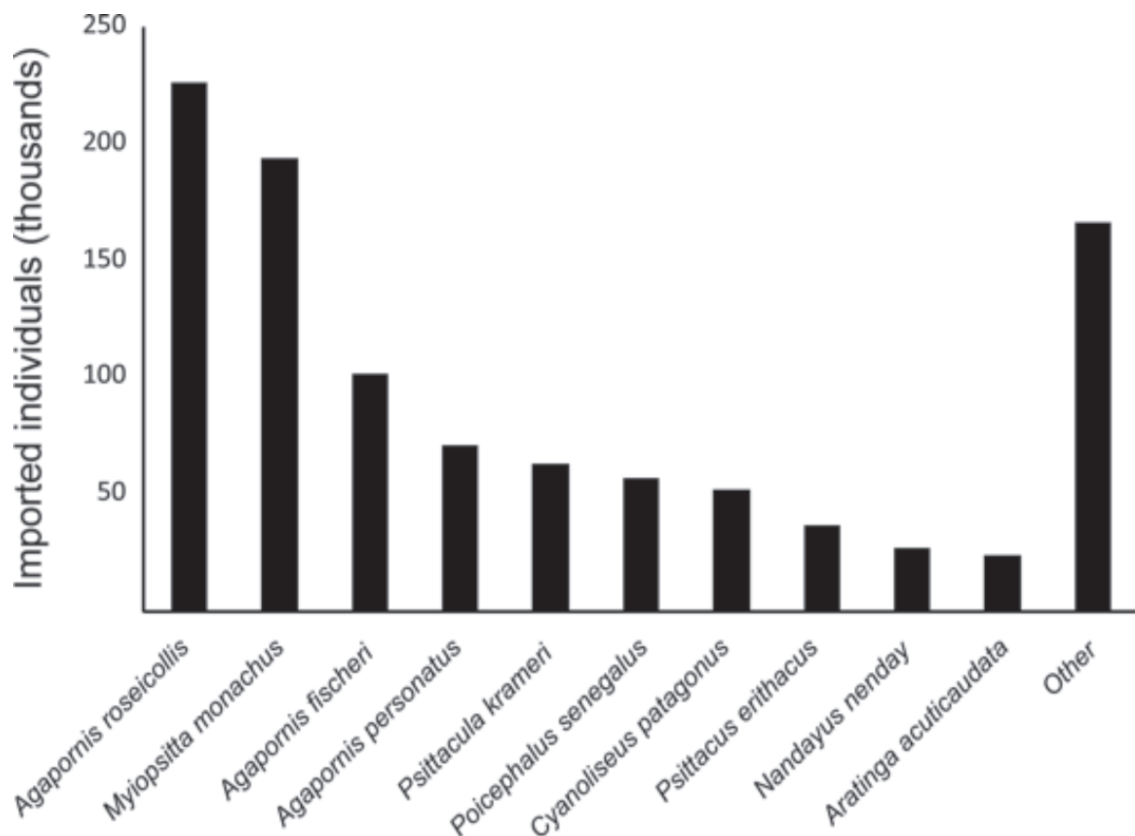


FIG. 1.—Number of Psittaciformers imported in Spain since CITES was implemented. The 10 most important species, out of a total of 252 reported, are indicated in the graph.

[Número de Psittaciformes importados desde que CITES fue implementado en España. El gráfico muestra las 10 especies más importadas, mientras que la categoría “otros” representa el resto (252 especies).]

## RESULTS

*Numbers, countries and destination of imported birds*

Between 1978 and 2015, more than 1 million parrots of 252 species were legally imported into Spain. Most birds belonged to three genera: *Agapornis* (409,417 individuals), *Myiopsitta* (194,086 individuals) and *Psittacula* (62,799 individuals, 95% of these being ring-necked parakeets). Monk and ring-necked parakeets were the second and fifth-most imported species respectively (Figure 1).

The most common country of origin for the Monk Parakeet was Uruguay (87%), followed by Argentina (13%). In the case of the Ring-necked Parakeet, the main exporting countries were Pakistan (77%) and Senegal (20%) (Figure 2). Most birds imported of both species were wild caught, though a large proportion of individuals (24% for the monk parakeet and 46% for the Ring-necked Parakeet) were declared of unknown origin

(Figure 3). Most individuals (99.9%) were imported as pets, the rest being imported for research purposes or exhibition in zoos.

*Import trends*

The first declared importations of Monk Parakeets and Ring-necked Parakeets occurred in 1986 and 1987, respectively. The last recorded importations in our database date from 2005 for both species. Peak importations for the monk parakeet occurred mainly during the period 1989-1995, while the Ring-necked Parakeet was mostly imported over the period 1998-2001 (Figure 4).

*Feral population numbers*

Monk and Ringed-necked Parakeet feral populations grew exponentially since first breeding populations were detected, after an establishment phase of approx. 10-20 years

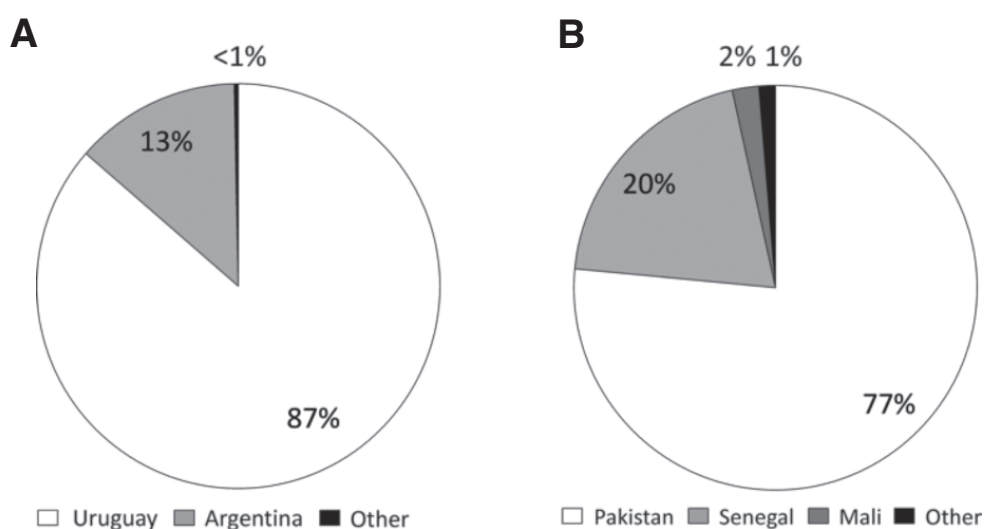


FIG. 2.—Most reported exporter countries for Monk (a) and Ring-necked Parakeets (b). Uruguay was the most common origin of the individuals imported for Monk Parakeet and Pakistan for Ring-necked Parakeet.

[Principales países exportadores de la cotorra argentina (a) y la cotorra de Kramer (b). Uruguay fue el origen más común para los individuos de cotorra argentina mientras que Pakistán lo fue para la de Kramer.]

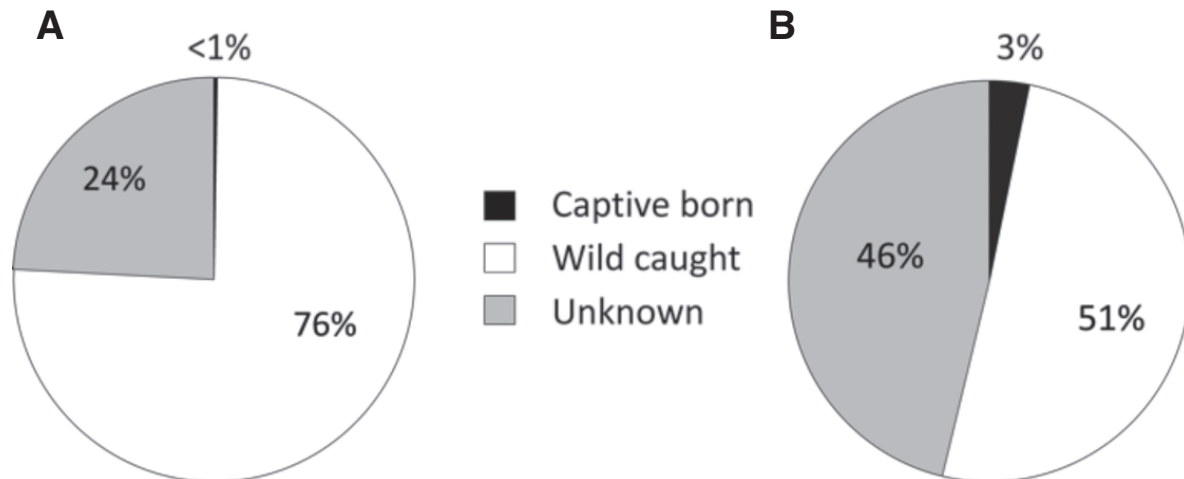


FIG. 3.—Proportion of individuals of Monk (a) and Ring-necked Parakeets (b) by source origin. The most amount the individuals of Monk Parakeet were captured from the wild and less than 1% were captive born. This proportion was bigger for Ring-necked Parakeet (3%) though it is quite small in comparison with the wild caught animals. A huge proportion of the animals' source origin was unidentified.

[Porcentaje de individuos de cotorra argentina (a) y de Kramer (b) según la fuente de origen. La inmensa mayoría de ejemplares de cotorra argentina procedieron de capturas en la naturaleza, con menos de 1% de animales procedentes de la cría en cautividad. Esta proporción fue más grande para la cotorra de Kramer (3%), pero muy pequeña en comparación con el número de ejemplares procedentes de capturas. Hubo un porcentaje considerable de ejemplares para ambas especies cuyo origen era desconocido.]

since initial observations. Original population estimates for monk parakeet in Spain were of around 1,300 individuals in 1997 (Muñoz & Ferrer, 1997), almost doubling by 2002 (Muñoz, 2003a). In 2015, the population size was 18,980-21,455 individuals throughout Spain (Molina *et al.*, 2016). For the Ring-necked Parakeet, the first population estimate was about 150 birds in 1997, tripled in 2002, and had multiplied by approximately 20 by 2015, with 3,005-3,115 estimated individuals (Muñoz, 2003b; Somoza *et al.*, 2017).

#### *Relationship between imports and wild populations*

Population increases in the wild were later than peak importation periods (1989-1995 for the Monk Parakeet, and 1997-2001 for the Ring-necked Parakeet). Feral populations of the two species grew exponentially throughout

the study period, with the population peaks in both cases occurring after importations ceased. The average annual growth rate (AAGR) between 1997 and 2002 for the Monk Parakeet was 167 animals per year. This number increased by a factor of almost 8 during the next 13 years, with an AAGR of 1,276 birds per year between 2002 and 2015. For the Ring-necked Parakeet, the AAGR between 1997 and 2002 was 26 animals per year, and again around 8 times higher, 206 animals, between 2002 and 2015.

#### DISCUSSION

##### *The magnitude of Monk and Ring-Necked parakeets trade in Spain*

Monk and Ring-necked Parakeets are abundant in their original ranges, and considered agricultural pests in some areas

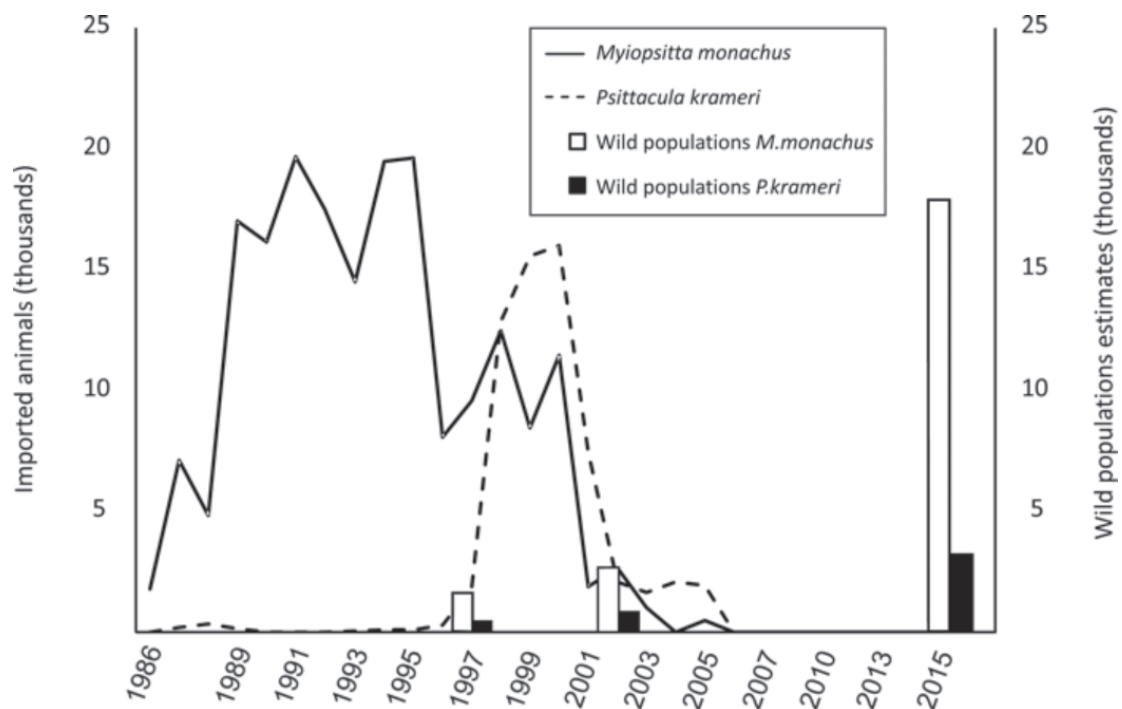


FIG. 4.—Comparison between the number of individuals of Monk and Ring-necked Parakeets legally introduced each year with the growth of their wild populations in Spain during the same study period. Lines represent the import of individuals mainly intended for commercial purposes, and bars represent population estimates and censuses for Monk and Ring-necked Parakeets, respectively.

[Comparación entre el número de individuos de cotorra argentina y de Kramer que fueron legalmente introducidos cada año con el crecimiento de las poblaciones naturalizadas en España durante el mismo periodo de estudio. Las líneas representan los especímenes importados principalmente por motivos comerciales, mientras que las barras representan las estimaciones poblacionales y censos de ambas especies.]

(Mott, 1973; Khan *et al.*, 2004; Volpe & Aramburú, 2011). This has enabled the collection and export of thousands of birds during decades. Both parakeet species have been the commonest and cheapest parrots available in pet shops in Spain until 2013, before the law prohibited their sale. In just 19 years, more than 190,000 birds of Monk and almost 63,000 Ring-necked Parakeets were legally imported into Spain, mostly to meet the demand for pet animals. This means that one in every four parrots that entered Spain belonged to these two mentioned species. These numbers are much higher than previously thought, however, this amount should be considered a minimum figure, since parrots are attractive in the black mar-

ket and a huge unreported number could have entered the country (Weston & Memon, 2009; Pires, 2012; Tella & Hiraldo, 2014). In addition, according to the net import CITES report, 258,273 Monk and 80,000 Ring-necked Parakeets were brought into Spain during 1975-2015, a higher figure than the reported numbers in the CITES comparative tabulation reports (see above).

#### *Origin of parakeets*

Our findings support recent genetic studies for both species in Spain (Edelaar *et al.*, 2015; Jackson *et al.*, 2015) that ring-necked parakeets in Spain comprised birds origi-



nating mostly from Asia (Muñoz, 2003a), as is the case for the UK (Pithon & Dytham, 2002) and the United States (Juniper & Parr, 1998). However, according to the CITES trade data base, we show that most birds (77%) came from Asia (*P. k. borealis*), but 20% of individuals had an African origin, belonging to the subspecies *P. k. krameri*. This is interesting, since there are hardly any wild African Ring-necked Parakeets in the naturalised populations in Spain. Cardador *et al.* (2016) suggested that the lack of wild-origin African individuals in comparison to their Asian counterparts may be due to the poor suitability of the Spanish environments, which would not allow them to adapt and establish successfully. For the Monk parakeet, nonetheless, our findings reaffirm that most feral individuals are *M. m. monachus*, a subspecies native to the South America region, between Uruguay and eastern Argentina. This is consistent with the genetic analyses by Rusello *et al.* (2008). Uruguay and Argentina are the main exporters for this species worldwide (Edelaar *et al.*, 2015).

#### *Why are Monk and Ringed-necked Parakeets so successful?*

According to our results, imported monk and Ringed-necked Parakeets in Spain were mostly captured from the wild, with a significant percentage of individuals with an unknown origin, being potentially wild-caught as well (Figure 3). It is well known that birds, which have been captured from the wild, are more adaptable and have higher success for establishing in case of release (Cabezas *et al.*, 2013; Abellan *et al.*, 2017). In contrast, animals which have been born into a controlled environment have difficulty in adapting to the wild if released or escaped, because they have not learnt the most important skills for surviving in nature and its ability to fly long

distances may be reduced (Cabezas *et al.*, 2013; Carrete & Tella, 2016). The genus *Agapornis* (lovebirds) is one of the most demanded psittaciformes in Spain, with three species being imported even in larger numbers than monk and ring-necked parakeets (Figure 1). However, almost 99% of the imported lovebirds were captive-born, which could be the main cause why these species have failed to establish themselves successfully in nature, even when the propagule pressure could have been larger.

#### *The evolution of Monk and Ring-necked Parakeets trade and feral populations in Spain*

According to the existing records both species in Spain date back to the 1970s (Perez-Chiscano, 1971; Clavell *et al.*, 1991). Although it is indicative of an international trade at that time, it is not possible to quantify monk and ring-necked parakeets imported before that date, as CITES was not implemented in Spain yet. Even so, the great popularity of these parakeets as pets in Spain was later compared to other regions of Europe and America, where self-sustaining populations were recorded during the 1960s and 1970s (Bull, 1973; Butler, 2003). Besides CITES, there are different regulations concerning the traffic of exotic birds, European and national, which have influenced trade for years (Santos, 2012). The tightening of the laws for the trade of Monk and Ring-necked Parakeets has been noteworthy. Monk Parakeets were popularized as pets in Spain during the 1980s-1990s (Santa-Olalla *et al.*, 2014), when laws were more permissive than today. The highest peaks occurred between 1989-1995, with almost 20,000 imported birds reported per year (Figure 4). In 1997, there was a strong importation decrease that coincided with the first wild population estimate (>1.300 established birds) (Martí & del

Moral, 2003). Importations were affected by the European Law “On the protection of species of wild fauna and flora by regulating trade therein” (Council Regulation –EC-338/97), which, in the article 4.6.d imposed “Limitations on live specimens of species for which it has been established that their introduction into the natural environment of the Community presents an ecological threat to wild species of fauna and flora indigenous to the Community”. When Monk Parakeet imports decreased, they were shortly after replaced in the market with the Ring-necked Parakeet (Figure 4).

The avian influenza crisis in the earlier 2000s severely affected the trade of domestic and exotic birds because of health alert worldwide (Van Borm *et al.*, 2005; Karesh *et al.*, 2005; Karesh *et al.*, 2007; Van den Berg, 2009). The European Union temporally banned the entrance of wild birds in 2005, and this measure became permanent in 2007 (Carrete & Tella, 2008). In Spain, more restricted laws were implemented in the following years regarding invasive species, banning completely the trade and possession of Monk and Ring-necked Parakeets (Real Decreto 630/2013). Even so, the last imported Monk Parakeet was reported in 2008.

Although there have been practically no imports of both species in 16 years, wild populations have grown in such a way that they can sustain themselves through breeding without the need of new introductions. There was an exponential growth of monk parakeet wild populations between 2002 and 2015, increasing from 2,300 to almost 18,000 birds. The growth was also significant for the Ring-necked Parakeet, which increased from 467 birds to over 3,000 in 13 years (SEO/BirdLife, 2016a, b).

In both cases, intentional or accidental releases currently play a key role in the appearance of new populations. The fear of possible fines regarding bird possession, as a result of the new regulatory restrictions, may

have played a role in it. This situation would be an example of how more tightening laws regarding to the control of the wildlife trade could paradoxically increase the problem of invasive species if they are not properly applied (Carrete & Tella, 2008).

*The wildlife trade of other Psittaciformes species in Spain and the hazard of introducing new potential invasive species*

Many other parrot species were and are imported to Spain with not many restrictions regulating their trade. The high demand in highly populated cities facilitates the presence of these birds in pet stores throughout the country (Gulx *et al.*, 1997; Weston & Memon, 2009). Several species of genera such as *Aratinga*, *Poicephalus* and *Nandayus*, have been seen in the wild in different parts of Spain, and some of them may be considered as potential breeders, although still in low numbers (Martínez-Santos & Grupo de Aves exóticas, 2012). The Senegal Parrot *Poicephalus senegalus* was the seventh most imported species in Spain, indicative of its commercial interest (Figure 1). Although it is not considered invasive in Spain and there are no specific laws prohibiting its possession and trade, it starts to appear as a breeding species in different parts of Spain as the Canary Islands, Valencia, Barcelona (Grupo de Aves exóticas, 2016) and Málaga (unpublished data). This species, probably in its first steps of the invasion process, could be another example of how legal wildlife trade in large scales facilitates the establishment of exotic and potentially invasive species. More preventive measures must be added regarding the trade of certain potentially invasive taxa, restricting (even banning) imports for commercial purposes. Education on the negative consequences of an uncontrolled international wildlife trade should play an important role in our society, in or-

der to prevent the potential consequences of this business on the conservation of biodiversity.

ACKNOWLEDGEMENTS.—ARM was supported by the Juan de la Cierva Program (FJCI-2014-20653), of the Spanish MECD. Partial funding was obtained by the Spanish Ministry of Agriculture, Food and Environment, Spanish National Park's Network (project 1098/2014). We thank the former director of SOIVRE Málaga, Arturo David Magno-Gómez and the Spanish CITES committee for the invaluable information provided for this article. We also thank Darío Chamorro for advice in the use of vector graphics editors.

AUTHOR'S CONTRIBUTIONS.—L. Souviron-Priego: Main author. She was responsible of writing most of the article, as well as the bibliography search. A. Román Muñoz: Main driver of developing this manuscript. He helped and advised to the main author on the structure of the manuscript. J. Olivero: Adviser. Helped and advised to the main author on the structure of the manuscript, especially in the methods section. J. Mario Vargas: Adviser. He helped in the first stages of the manuscript. J.E. Fa: Main adviser. He was in charge of giving the final assessment, as well as fine-tuning the grammatical structure in English.

## REFERENCES

- Abellán, P., Carrete, M., Anadón, J.D., Cardador, L. & Tella, J.L. (2016). Non-random patterns and temporal trends (1912-2012) in the transport, introduction and establishment of exotic birds in Spain and Portugal. *Diversity and Distributions*, 22: 263-273.
- Abellán, P., Tella, J.L., Carrete, M., Cardador, L. & Anadón, J.D. (2017). Climate matching drives spread rate but not establishment success in recent unintentional bird introductions. *Proceedings of the National Academy of Sciences*, 114: 201704815.
- Avery, M.L., Greiner, E.C., Lindsay, J.R., Newman, J.R. & Pruett-Jones, S. (2002). Monk Parakeet management at electric utility facilities in South Florida. *Proceedings 20th. of the Vertebrate Pest Conference*, 20: 140-145.
- Batllo, X. & Nos, R. (1985). Presencia de la cotorrita gris (*Myiopsitta monachus*) y de la cotorrita de collar (*Psittacula krameri*) en el área metropolitana de Barcelona. *Miscellanea zoológica*, 9: 407-411.
- BirdLife International (2014). Available at: <http://datazone.birdlife.org/home>.
- Bull, J. (1973). Exotic birds in the New York city area. *The Wilson Bulletin*, 85: 501-505.
- Bush, E.R., Baker, S.E. & Macdonald, D.W. (2014). Global trade in exotic pets 2006-2012. *Conservation biology: the journal of the Society for Conservation Biology*, 28: 663-676.
- Butler, C.J. (2003). *Population biology of the introduced rose-ringed parakeet Psittacula krameri in the UK*. University of Oxford. United Kingdom.
- Cabezas, S., Carrete, M., Tella, J.L., Marchant, T.A. & Bortolotti, G.R. (2013). Differences in acute stress responses between wild-caught and captive-bred birds: A physiological mechanism contributing to current avian invasions? *Biological Invasions*, 15: 521-527.
- Cardador, L., Carrete, M., Gallardo, B. & Tella, J.L. (2016). Combining trade data and niche modelling improves predictions of the origin and distribution of non-native European populations of a globally invasive species. *Journal of Biogeography*, 43: 967-978.
- Cardador, L., Lattuada, M., Strubbe, D., Tella, J.L., Reino, L., Figueira, R. & Carrete, M. (2017). Regional bans on wild-bird trade modify invasion risks at a global scale. *Conservation Letters*, 0: 1-9.
- Carrete, M. & Tella, J. (2008). Wild-bird trade and exotic invasions: a new link of conservation concern? *Frontiers in Ecology and the Environment*, 6: 207-211.
- Carrete, M. & Tella, J.L. (2016). Rapid loss of anti-predatory behaviour in captive-bred birds is linked to current avian invasions. *Scientific Reports*, 5: 18274.
- CITES (2013). *A guide to using the CITES Trade Database*.
- CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) (2016). Available at: <https://trade.cites.org/>

- Clavell, J., Martorell, E., Santos, D.M. & Sol, D. (1991). Distribució de la Cotorreta de Pit Gris *Myopsitta Monachus* a Catalunya. *Butlletí del Grup Català d'Anellament*, 8: 15-18.
- Czajka, C. (2011). Resource use by non-native Ring-necked Parakeets (*Psittacula krameri*) and native Starlings (*Sturnus vulgaris*) in Central Europe. *The Open Ornithology Journal*, 4: 17-22.
- DAISIE (2009). *Handbook of Alien Species in Europe*. Springer Netherlands. Dordrecht.
- Davis, L.R. (1974). The monk parakeet: A potential threat to agriculture. *Proceedings of the 6th Vertebrate Pest Conference*, 253-256.
- Driscoll, C.A. & Macdonald, D.W. (2010). Top dogs: wolf domestication and wealth. *Journal of biology*, 9: 10.
- Edelaar, P., Roques, S., Hobson, E.A., Gonçalves da Silva, A., Avery, M.L., Russello, M.A., Senar, J.C., Wright, T.F., Carrete, M. & Tella, J.L. (2015). Shared genetic diversity across the global invasive range of the monk parakeet suggests a common restricted geographic origin and the possibility of convergent selection. *Molecular Ecology*, 24: 2164-2176.
- Grupo de Aves exóticas (SEO/BirdLife) (2016). *Cuaderno de especies invasoras*. Available: [http://grupodeavesexoticas.blogspot.com.es/search/label/Poicephalus senegalus](http://grupodeavesexoticas.blogspot.com.es/search/label/Poicephalus%20senegalus)
- Gulx, J.C., Jover, L. & Ruiz, X. (1997). Muestreos del comercio de psitácidos neotropicales en la ciudad de Barcelona, España: 1991-1996. *Ararajuba*, 5: 159-167.
- Hernández-Brito, D., Carrete, M., Popa-Lisseanu, A.G., Ibáñez, C. & Tella, J.L. (2014). Crowding in the city: Losing and winning competitors of an invasive bird. *PLoS ONE*, 9: e100593.
- Hughes, J.D. (2003). Europe as Consumer of Exotic Biodiversity: Greek and Roman times. *Landscape Research*, 28: 21-31.
- Hulme, P.E., Roy, D.B., Cunha, T. & Larsson, T.B. (2009). A pan-European inventory of alien species: Rationale, implementation and implications for managing biological invasions. *Handbook of Alien Species in Europe*, pp. 1-14. Springer Netherlands, Dordrecht.
- Jackson, H., Strubbe, D., Tollington, S., Prys-Jones, R., Matthysen, E. & Groombridge, J.J. (2015). Ancestral origins and invasion pathways in a globally invasive bird correlate with climate and influences from bird trade. *Molecular Ecology*, 24: 4269-4285.
- De Juana, E. (1985). Cotorra Argentina *Myiopsitta monachus*. Noticiario ornitológico. *Ardeola*, 80: 309-310.
- De Juana, E. (1989). Cotorra de Kramer *Psittacula krameri*. Noticiario ornitológico. *Ardeola*, 36: 231-264.
- Juniper, T. & Parr, M. (1998). *Parrots: a guide to the parrots of the world*. Yale University Press. Pica. Robertsbridge.
- Karesh, W.B., Cook, R.A., Bennett, E.L. & Newcomb, J. (2005). Wildlife trade and global disease emergence. *Emerging infectious diseases*, 11: 1000-1002.
- Karesh, W.B., Cook, R.A., Gilbert, M. & Newcomb, J. (2007). Implications of wildlife trade on the movement of avian influenza and other infectious diseases. *Journal of Wildlife Diseases*, 43: S55-59.
- Khan, H.A., Beg, M.A. & Khan, A.A. (2004). Breeding habitats of the Rose-ringed parakeet (*Psittacula krameri*) in the cultivations of central Punjab. *Pakistan Journal of Zoology*, 36: 133-138.
- Kisling, Jr, V.N. (2000). *Zoo and Aquarium History: Ancient Animal Collections To Zoological Gardens*. Kisling, V.N., Jr. (Ed.). Boca Raton. Florida.
- Martí, R. & del Moral, J.C. (2003). *Atlas de las aves reproductoras de España*. Sociedad Española de Ornitología (SEO/BirdLife). Madrid.
- Martínez-Santos, D. & Grupo de Aves exóticas (SEO/BirdLife) (2012). Especies establecidas (categoría C) presentes en España durante la realización del trabajo de campo de este atlas. *Atlas de las aves en invierno en España 2007-2010*, pp. 628-640. Ministerio de Agricultura, Alimentación y Medio Ambiente-SEO/BirdLife. Madrid.
- Mazza, G., Tricarico, E., Genovesi, P. & Gherardi, F. (2014) Biological invaders are threats to human health: an overview. *Ethology, Ecology and Evolution*, 26: 112-129.
- Menchetti, M. & Mori, E. (2014). Worldwide impact of alien parrots (Aves Psittaciformes) on native biodiversity and environment: a review. *Ethology, Ecology & Evolution*, 26: 172-194.

- Menchetti, M., Scalera, R. & Mori, E. (2014). First record of a possibly overlooked impact by alien parrots on a bat (*Nyctalus leisleri*). *Hystrix*, 25: 61-62.
- Ministerio de Agricultura & Medio Ambiente (2013). *Real Decreto 630/2013, de 2 de agosto, por el que se regula el Catálogo Español de Especies Exóticas Invasoras*.
- Molina, B., Postigo, J.L., Muñoz, A.R. & del Moral, J.C. (2016). *La cotorra argentina en España: Población reproductora en 2015 y método de censo*. SEO/BirdLife. Madrid.
- Mori, E., Grandi, G., Menchetti, M., Tella, J.L., Jackson, H.A., Reino, L., Kleunen, A. Van Figueira, R. & Ancillotto, L. (2017). Worldwide distribution of non-native Amazon Parrots and temporal trends of their global trade worldwide distribution of non-native Amazon Parrots and temporal trends of their global trade. *Animal Biodiversity and Conservation*, 1: 49-63.
- Mott, D.F. (1973). Monk Parakeet damage to crops in Uruguay and its control. *Bird Control Seminars Proceedings*. University of Nebraska. Lincoln.
- Muñoz, A.R. (2003a). Cotorra Argentina, *Myiopsitta monachus*. *Atlas de las aves reproductoras de España* (ed. by R. Martí and J.C. del Moral), pp. 638-639. Sociedad Española de Ornitología (SEO/BirdLife). Madrid.
- Muñoz, A.R. (2003b). Cotorra de Kramer, *Psittacula krameri*. *Atlas de las aves reproductoras de España* (ed. by R. Martí and J.C. del Moral), pp. 636-637. Sociedad Española de Ornitología (SEO/BirdLife). Madrid.
- Muñoz, A.R. (2016). Modelo predictivo de distribución. *La cotorra argentina en España, población reproductora en 2015 y método de censo* (ed. by B. Molina, J.L. Postigo, A.-R. Muñoz, and J.C. del Moral), pp. 54. SEO/BirdLife. Madrid.
- Muñoz, A.R., Carrasco, E., Souviron-Priego, L. & Real, R. (2017). El uso de modelos de favorabilidad para interpretar la distribución actual y predecir la distribución futura de la cotorra de Kramer en España peninsular. *La cotorra de Kramer en España, población reproductora en 2015 y método de censo. España peninsular* Madrid.
- Muñoz, A.R. & Ferrer, X. (1997). Cotorra argentina *Myiopsitta monachus*. *Atlas de las Aves de España (1975-1995)* (ed. by F.J. Purroy), pp. 248-249. Barcelona.
- Muñoz, A.R. & Real, R. (2006). Assessing the potential range expansion of the exotic monk parakeet in Spain. *Diversity and Distributions*, 12: 656-665.
- Natusch, D.J.D. & Lyons, J.A. (2012). Exploited for pets: the harvest and trade of amphibians and reptiles from Indonesian New Guinea. *Biodiversity and Conservation*, 21: 2899-2911.
- Oldfield, S. (2003). *The trade in wildlife: regulation for conservation*. Earthscan Publications (Ed.). London.
- Pôrão, L.G., Strubbe, D., Mori, E., Menchetti, M., Ancillotto, L., van Kleunen, A., White, R.L., Luna, Á., Hernández-Brito, D., Le Louarn, M., Clergeau, P., Albayrak, T., Franz, D., Braun, M.P., Schroeder, J. & Wink, M. (2016). Rose-ringed Parakeet populations and numbers in Europe: A complete overview. *The Open Ornithology Journal*, 9: 1-13.
- Peck, H.L., Pringle, H.E., Marshall, H.H., Owens, I.P.F. & Lord, A.M. (2014). Experimental evidence of impacts of an invasive parakeet on foraging behavior of native birds. *Behavioral Ecology*, 25: 582-590.
- Pérez-Chiscano, J. (1971). Captura de *Psittacula k. krameri* (Scopoli) en el SE de la provincia de Cáceres. *Ardeola*, 15: 144-145.
- Phelps, J., Biggs, D. & Webb, E.L. (2016). Tools and terms for understanding illegal wildlife trade. *Frontiers in Ecology and the Environment*, 14: 479-489.
- Pires, S.F. (2012). The illegal parrot trade: a literature review. *Global crime*, 13: 37-41.
- Pithon, J.A. & Dytham, C. (2002). Distribution and population development of introduced Ring-necked Parakeets *Psittacula krameri* in Britain between 1983 and 1998. *Bird Study*, 49: 110-117.
- Postigo, J.L., Shwartz, A., Strubbe, D. & Muñoz, A.R. (2016). Unrelenting spread of the alien Monk Parakeet *Myiopsitta monachus* in Israel. Is it time to sound the alarm? *Pest Management Science*, 73: 349-353.
- Purroy, F.J. (1997). *Atlas de las Aves de España 1975-1995*. Lynx Editions (Ed.). Barcelona.
- Real, R., Márquez, A.L., Estrada, A., Muñoz, A.R. & Vargas, J.M. (2008). Modelling chorotypes of

- invasive vertebrates in mainland Spain. *Diversity and Distributions*, 14: 364-373.
- Reino, L., Figueira, R., Beja, P., Araújo, M.B., Capinha, C. & Strubbe, D. (2017). Networks of global bird invasion altered by regional trade ban. *Science Advances*, 3: e1700783.
- Rosen, G.E. & Smith, K.F. (2010). Summarizing the evidence on the international trade in illegal wildlife. *EcoHealth*, 7: 24-32.
- Russello, M. A., Avery, M.L. & Wright, T.F. (2008). Genetic evidence links invasive monk parakeet populations in the United States to the international pet trade. *BMC evolutionary biology*, 8: 217.
- Santa-Olalla Adell, A., Paals-González, C., Guerrero-Moreno, A., Arnas-Parellada, J., Lázaro-Rubio, M., Pérez Gordillo, J., Martínez-Torres, R., Lorenzo-Íñigo, I. & Pirvu, M. (2014). *Código de conducta para evitar el comercio de fauna exótica invasora*. Madrid.
- Santos, D.M. (2012). *Legislación sobre aves exóticas*. Grupo de Aves Exóticas. SEO/BirdLife.
- SEO/BirdLife (2016a). Available at: <http://www.seo.org/2015/11/11/lanzamos-los-datos-del-primer-censo-nacional-de-cotorra-argentina/>
- SEO/BirdLife (2016b). Available at: <http://www.seo.org/2016/07/13/lanzamos-los-resultados-del-i-censo-nacional-cotorra-kramer/>
- Simberloff, D. (2014). Biological invasions: What's worth fighting and what can be won? *Ecological Engineering*, 65: 112-121.
- Smith, K.M., Anthony, S.J., Switzer, W.M., Epstein, J.H., Seimon, T., Jia, H., Sanchez, M.D., Huynh, T.T., Galland, G.G., Shapiro, S.E., Sleeman, J.M., McAloose, D., Stuchin, M., Amato, G., Kolokotronis, S.O., Lipkin, W.I., Karesh, W.B., Daszak, P. & Marano, N. (2012). Zoonotic viruses associated with illegally imported wildlife products. *PloS one*, 7: e29505.
- Sol, D., Santos, D.M., Fera, E. & Clavell, J. (1997). Habitat selection by the Monk Parakeet during colonization of a new area in Spain. *The Condor*, 99: 39-46.
- Somoza, A., Molina, B., Muñoz, A.R. & del Moral, J.C. (2017). *La cotorra de Kramer en España: Población reproductora en 2015 y método de censo*. SEO/BirdLife. Madrid.
- Stafford, T. (2003). *Pest risk assessment for Monk Parakeet in Oregon*. Oregon.
- Strubbe, D. & Matthysen, E. (2007). Invasive ring-necked parakeets *Psittacula krameri* in Belgium: Habitat selection and impact on native birds. *Ecography*, 30: 578-588.
- Strubbe, D. & Matthysen, E. (2009a). Establishment success of invasive ring-necked and monk parakeets in Europe. *Journal of Biogeography*, 36: 2264-2278.
- Strubbe, D. & Matthysen, E. (2009b). Experimental evidence for nest-site competition between invasive ring-necked parakeets (*Psittacula krameri*) and native nuthatches (*Sitta europaea*). *Biological Conservation*, 142: 1588-1594.
- Tala, C., Guzmán, P. & González, S. (2005). Cotorra argentina (*Myiopsitta monachus*) convalidado de piedra en nuestras ciudades y un invasor potencial, aunque real, de sectores agrícolas. *Boletín Diproren*, 1-7.
- Tella, J.L. & Hiraldo, F. (2014). Illegal and legal parrot trade shows a long-term, cross-cultural preference for the most attractive species increasing their risk of extinction. *PLoS ONE*, 9: e107546.
- Turbè, A., Strubbe, D., Mori, E., Carrete, M., Chiron, F., Clergeau, P., González-Moreno, P., Le Louarn, M., Luna, A., Menchetti, M., Nentwig, W., Parau, L.G., Postigo, J.L., Rabitsch, W., Senar, J.C., Tollington, S., Vanderhoeven, S., Weiserbs, A. & Shwartz, A. (2017). Assessing the assessments: evaluation of four impact assessment protocols for invasive alien species. *Diversity and Distributions*, 23: 297-307.
- Ucko, P.J. & Dumbleby, G. (1969). *The Domestication and Exploitation of Plants and Animals*. Routledge (Ed.). Chicago.
- Van Borm, S., Thomas, I., Hanquet, G., Lambrecht, B., Boschmans, M., Dupont, G., De caestecker, M., Snacken, R. & Van den Berg, T. (2005). Highly pathogenic H5N1 influenza virus in smuggled Thai eagles, Belgium. *Emerging infectious diseases*, 11: 702-705.
- Van den Berg, T. (2009). The role of the legal and illegal trade of live birds and avian products in the spread of avian influenza. *Revue scientifique et technique (International Office of Epizootics)*, 28: 93-111.
- Volpe, N.L. & Aramburú, R.M. (2011). Preferencias de nidificación de la cotorra argentina

- (*Myiopsitta monachus*) en un área urbana de Argentina. *Ornitología Neotropical*, 22: 111-119.
- Weston, M.K. & Memon, M.A. (2009). The illegal parrot trade in Latin America and its consequences to parrot nutrition, health and conservation. *Bird Populations*, 9: 76-83.
- Williams, T.L. (1956). *Man's role in changing the face of the earth*. University of Chicago Press (Ed.). USA.
- Yosef, R., Zduniak, P. & Żmihorski, M. (2016). Invasive Ring-necked Parakeet negatively affects

indigenous Eurasian Hoopoe. *Annales Zoologici Fennici*, 53: 281-287.

*Submitted: December 30, 2017*

*Minor revision: February 08, 2018*

*Second version arrives: February 22, 2018*

*Accepted: February 23, 2018*

Editor: Christophe Barbraud

