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Studies on the Rose-ringed Parakeet *Psittacula krameri* colony of Genoa (Liguria, NW Italy)

Valeria Gereschi[1], Loris Galli[2] & Enrico Borgo[3]*

[1]Via Papa Giovanni XXIII 28, 29020 Vigolzone (PC), Italy
[2]Department of Earth, Environmental and Life Sciences (DISTAV), Genoa University, Corso Europa 26, 16132 Genoa, Italy
[3]Museo Civico di Storia Naturale "G. Doria", Via Brigata Liguria 9, 16121 Genoa, Italy
*corresponding author: eborgo@comune.genova.it

0000-0002-8920-8881

Abstract - Taking into account that the previous quantitative data relating to the Rose-ringed Parakeet *Psittacula krameri* of Genoa (Liguria, Italy) dates back to 2009 and considering the potential impact that an alien species can have on native ones and the environment, the Genoese population of this species was studied during the years 2016-2018 to quantify its size and trend in recent years. Counts at roost resulted in a total of approximately 630 individuals, allowing us to outline the increase of the population since the first records in the 1970s: the number of individuals has rised from 46 in 1993 to more than 600 today. Data on food resources used were collected and the list of plants that parakeets feed on has been expanded. Interactions with local fauna were investigated: they turned out to be few and related to Jackdaw *Corvus monedula* and Urban Pigeon *Columba livia* var. *domestica*. Impacts on citizens and their activities were more consistent: damages to vegetables and garden crops were observed and the presence of roosting sites caused filth and noise. The main travel routes to and from the main dormitories were also detected during the censuses. We could also confirm the disappearance from the territory of Genoa city of the Monk Parakeet *Myiopsitta monachus.*

Keywords: alien species, human-wildlife interaction, invasive species, Psittaciformes, urban avifauna, urban habitat

INTRODUCTION

The Rose-ringed Parakeet *Psittacula krameri* (Scopoli, 1769) is considered one of the 100 worst invasive alien species (IAS) in Europe (DAISE 2009) with a strong impact on the environment; for this reason, monitoring the demographic trend of this (as well as of other) invasive species could be crucial, given the impact they can have on native species and even on the human population due to noise, damages to infrastructures, and hygienic issues.

During the last 40 years, there has been in the world a marked increase in the number of localities where the presence of Rose-ringed Parakeet non-indigenous populations have been found (from 27 in 1986 to 31 in 2006, up to 101 in 2016). A parallel increase was recorded also for confirmed breeding sites (outside the native range): from 5 in 1986 to 90 in 2016 (Mori et al. 2013; Mori et al. 2020; Jackson et al. 2015; Luna et al. 2016; Pârâu et al. 2016; Rocha et al. 2020; Calzada Preston & Pruett-Jones 2021; Viviano & Mori 2021).

In Italy, the Rose-ringed Parakeet is widespread in almost all regions and it also nests in most of them; in Liguria, this species breeds mainly in the city of Genoa, with some evidence of possible and probable nesting coming from a few other localities in the

provinces of Imperia and Genoa (Lardelli R. personal communication). The first individuals, observed starting from the 1970s, were limited to only two districts of the city characterized by a widespread presence of green areas, Albaro and Castelletto, with an estimate of maximum 10-20 individuals (Spanò & Truffi 1986). The first breeding pairs were found in the latter area, on *Cedrus atlantica* and *Cupressus sempervirens* inside Villa Gruber (Maranini & Galuppo 1994). In the period 1996-2000, the species was still mainly concentrated in the central-eastern part of the city and it was estimated at one hundred individuals (Borgo et al. 2005).

Given that previous data on the population size of the Rose-ringed Parakeets date back to 2009 (Borgo & Galuppo unpub.), the colony of Rose-ringed Parakeet in the city of Genoa was studied between June 2016 and May 2018 to assess the state of the population, analyze its evolution and estimate the current number of birds through counts in the roosts, in order to obtain more up-to-date information for monitoring this invasive species. At the same time, data has been collected on the trophic resources used by parakeets, as well as on their movements within the urban area.

MATERIALS AND METHODS

Study area

The study area corresponds to the urban centre of the city of Genoa (Liguria, Italy) (Fig. 1), from Voltri

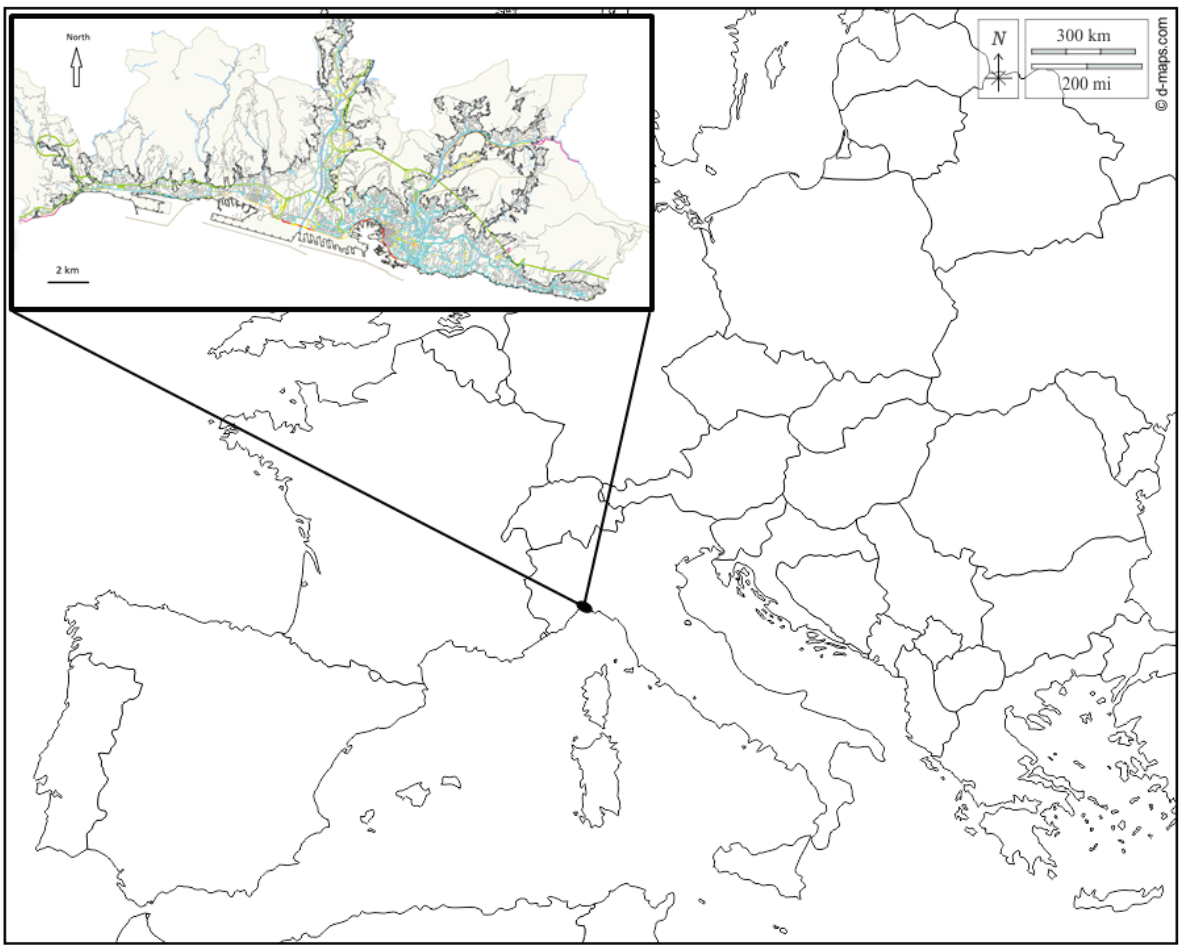

Figure 1. The city of Genoa in Liguria (NW Italy).

(West) to Nervi along the coast up to the heights of Val Polcevera and Val Bisagno (Murta, to the West, and Bavari, to the East) (Fig. 2). It is a thin portion of territory compressed between sea and mountains, characterized, according to the Köppen-Geiger classification (Geiger 1954), by two main climatic typologies: the Mediterranean warm temperate climate with summer drought (Csa) along the coastal strip, especially in the West, and the Climate temperate transition to the Mediterranean (Cfsa), in the easternmost and inner part of the city (PUC 2015).

Range and size estimation of Genoese Rose-ringed Parakeet population

The main flight routes, from dormitories to feeding areas and/or daytime use areas, were defined through observations carried out at sunrise and sunset and reported on a map of the city. Observation sessions were made in subsequent days (150 days of field observations, for a total of about 600 hours, in the period September 2016-March 2018) and the directions of origin and departure of the groups of individuals were reported.

The main roost (via Cecchi, Fig. 2, n. 1) was already known (Vergano 1998; Borgo et al. 2005), while the occurence of a second one (Piazza Baracca, Fig. 2, n. 2), whose presence was uncertain, was verified. To monitor the use of roosts and identify the best time to make the counts, at least one monthly check was made during the study period, for a total of 24 checks. The censuses were carried out in Piazza Baracca and Via Cecchi, at sunset, photographing with a digital camera the trees against the light. In the considered period, two counts were carried out, in February 2017 and January 2018. The backlight photographs were taken using the residual light immediately after sunset. To obtain sufficiently reliable counts, it was necessary to make several factors coincide: the regular presence of parakeets in that particular roost, optimal weather conditions such as little wind, good visibility, and residual light at sunset. Above all, the trees needed to have lost as many leaves as possible to avoid problems in recognizing the parakeets silhouettes. The resulting photographs were examined on the PC, enlarging them to better identify the parakeets. The photographs were examined by at least two people separately (authors and collaborators), and the results were compared.

The trend of population since 1993, obtained from data taken from the literature or unpublished and provided by collaborators (see Tab. 1), was analyzed by performing a linear regression of the logarithm of parakeets number, using the software PAST 4.02 (Paleontological Statistics version 4.02, Hammer et al. 2001).

In addition to the naturalized population of Genoa, data on the presence of the species in Liguria that refer to various other locations was taken from www.liguriabirding.net. and the iNaturalist and Ornitho.it databases (accessed 21.IV.2022).

Analysis of the diet

The main trophic resources used by this species in the study area were identified through direct observations and based on the information received from occasional collaborators/observers who have provided data or photographs, and from data obtained from the literature (Vergano 1998).

Survey of the nesting activities

During the field survey, data were also collected on the nesting of the Rose-ringed Parakeet, trying to identify the most used areas and the types of the nest (holes in walls or houses, hollows in trees, etc.).

Analysis of interactions with wildlife

Due to the potential impact on native wildlife of this alien species, any cases of interaction between parakeets and other species were also recorded as far as possible, particularly in areas where the parakeets nest or during their feeding activity.

Analysis of interactions with human activities

In order to gather data on the distribution, feeding, and any related problem created by the parakeets, during the survey, impressions and statements

expressed by a hundred citizens both inhabitants of the center and the periphery of Genoa were collected. Much of this information was collected in a "colloquial" way or through a third party; very often people, especially the owners of gardens or similar crops, have proved unwilling to provide accurate information or participate in an official data collection. Unfortunately, this method of collecting information prevented any quantitative elaboration of these data. On a couple of occasions, further information has been obtained from in-depth articles on the subject by the local press.

RESULTS

Range and size of Genoese population

Through this investigation, it has been possible to locate foraging areas, dormitories, and flight routes, even if over time the parakeets seem to have adapted to exploit more widely the resources of the city territory making the observation of large groups of individuals less and less frequent, with the exception of the roosts.

Originally, following the involuntary introduction of this species in Genoa in the second half of the 1970s, parakeets were concentrated in the Castelletto district, located in the center (Vergano 1998), close to the harbor, the most probable starting area of the spread of this species. Over the years there has been a considerable range increase, both longitudinally and latitudinally, but mainly along the coast in the East-West direction, where anthropization is greater (Maranini & Galuppo 1994; Borgo et al. 2005). Currently, the Rose-ringed Parakeet occurs permanently in all the districts of the city, with the greatest concentrations on the coast and in the green areas, although sightings are increasingly frequent even at higher altitudes, for example in Val Bisagno at the Sella di Bavari (about 300 m a.s.l.) in the eastern part, as well as at Murta (185 m a.s.l.) in Val Polcevera (Fig 2).

The counts carried out at the two roosts gave results fairly in line with what was expected and hypothesized through daytime observations (i.e. 400-500 parakeets): in total about 626 individuals in 2017 (an estimated 426 individuals at the roost of Via Cecchi and about 200 individuals at the roost of Piazza Baracca) and 630 individuals in 2018 (about 430 individuals at the roost of Via Cecchi and about

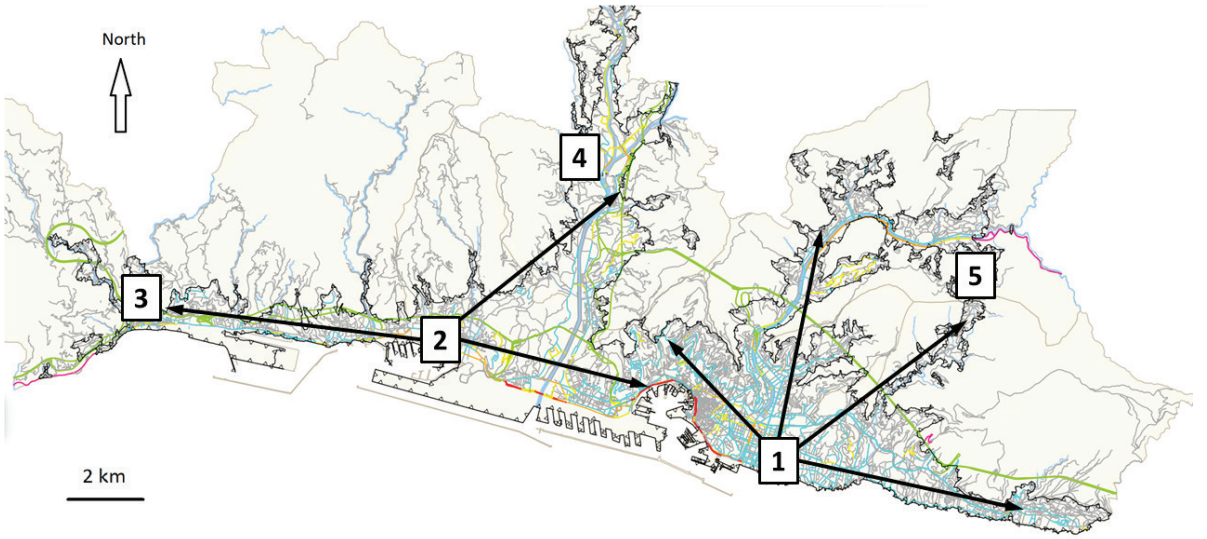

Figure 2. Location of the main localities attended by the Rose-ringed Parakeet in Genoa and main flight routes: 01 – Roost of Via Cecchi; 02 – Roost of Piazza Baracca; 03 – Voltri; 04 – Murta; 05 – Bavari.

200 individuals at the roost of Piazza Baracca). The geographical spread was obviously related to the numerical increase of the population: in the last 30 years the number of Rose-ringed Parakeet has increased by 13 times, passing from about 46 individuals, detected in 1992-1993 (Maranini & Galuppo 1994), to more than 600 individuals in the two-year period 2016-2018 (Tab.1).

Table 1. Estimates of the Genoese Rose-ringed Parakeet population since 1993 basing on literature and the present study

Number of birds	Year	Source
46	1993	Maranini & Galuppo 1994
60	1998	Vergano (1998)
100	2005	Borgo et al. 2005
385	2009	Borgo & Galuppo (pers. com.)
626	2017	
630	2018	

Figure 3 shows that the Genoese population of Rose-ringed Parakeet increased rather fast from 1993 to 2018 ($t = 8{,}33$, $df = 4$, $P < 0.01$; $R2 = 0.94$). Following the indications in Butler (2003), we extrapolated from this linear model the future population of Rose-ringed Parakeets.It can be predicted that in 2026, Genoa could host 3540 individuals, provided that the climatic and environmental conditions remain as favorable as now.

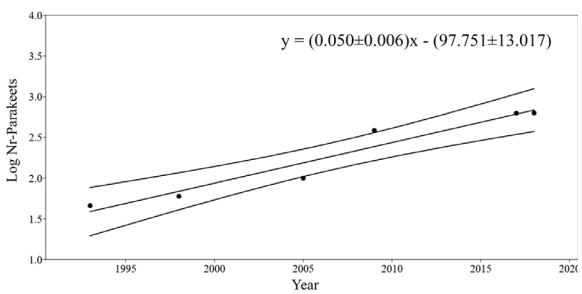

Figure 3. Trend of the Genoese Rose-ringed Parakeet population based on data collected from 1993 to 2018. Population size is log (base 10) transformed. Regression line and 95% interval are drawn. The regression formula is shown at the top right corner: for slope and intercept, standard error values are given.

Currently, the parakeets use two main places to meet and sleep: Via Antonio Cecchi (Fig. 2, n. 1), in the central-eastern part of Genoa, and Piazza Francesco Baracca, in the western part of the city (Fig. 2, n. 2). The first roost is sometimes replaced with a neighboring one (Via Piave), located about 0.72 km to the East. Roosts are often shared with other species, in particular the Jackdaw *Corvus monedula* and, more rarely, the Blue-fronted Amazon *Amazona aestiva*.

Parakeets generally select, as roosting sites, places characterized by a milder temperature than the surroundings and protected from the wind. These roosts have very similar characteristics: they are close to the sea, which guarantees a favorable microclimate, and are made up of two rows of Platanus trees, close to each other and located between two rows of buildings as tall as trees or more, ensuring a certain degree of shelter from the wind. However, they differ in their orientation with respect to the coastline: the one in Via Cecchi develops parallel to the coastline, while the one in Via Piave and the one in Piazza Baracca develop perpendicularly to it.

Considering the directions of arrival of the parakeets at sunset, the roost in Piazza Baracca is regularly used by the individuals that frequent the western part of the city during the daytime hours, while the roosts of Via Cecchi and Via Piave host the parakeets active in the central and eastern parts of Genoa. The former represents for these birds the main roost, frequented for most of the year (18 out of 24 visits, i.e. 75% of the time). However, a displacement of the individuals from Via Cecchi to Via Piave has occurred multiple times, even resulting in a stay of several weeks, overall for 25% of the study period. Contrary to what Vergano (1998) observed, in the two-year period 2016-2018 the simultaneous use of these two roosts was never found; indeed, all the individuals always moved together from one roost to the other. Only once in mid-January 2017, the first change we recorded, the movement of parakeets did affect only a part of the group.

An ancillary result deriving from this investigation, is the confirmation of the disappearance from the

territory of Genoa of the Monk Parakeet *Myiopsitta monachus*, regularly present until 1995 and then observed sporadically (1-2 individuals) until 2005 (Borgo et al. 2005).

Diet

The Rose-ringed Parakeet is a granivorous and frugivorous species and its diet consists mainly of fruits, seeds, flowers, and buds (Cramp 1985; Juniper & Parr 2003). From this point of view, the city of Genoa offers these parakeets a great variety of food sources, from the areas closest to the coast to the hills behind the town. During this study, the exploitation of multiple species of plants by parakeets for foraging was observed (Tab. 2). In this area, the trophic resources are exploited in a fairly widespread and opportunistic way; for this reason, it is hard to estimate the percentage of use of each plant species.

It was also noted that the parakeets usually prefer to feed on the higher branches, rarely landing on the ground. In some cases, they collected food and moved to higher and/or safer position to consume it.

Nesting

Breeding colonies are scattered throughout the city, making it difficult to accurately locate all breeding sites. In Genoa, the Rose-ringed Parakeet nests mainly in cavities in the walls of buildings and, less frequently, in tree hollows. Indeed, despite the numerous and widespread green areas, sometimes large, both public and private, tree cavities are quiet scarce, especially following the maintenance treatments to which the largest trees are subjected, and only two nests in trees were recorded during the study period, both on *Pinus* sp. plants.

The Rose-ringed Parakeet made its first appearance in Genoa in the mid-1970s and a few years later the first breeding attempt was recorded in Villa Gruber (Galuppo, pers. com.; Maranini & Galuppo 1994). According to the Ornithological Atlas of the city of Genoa (Borgo et al. 2005), between 1996 and 2000 the Rose-ringed Parakeet nested in 6.7% of the city area. Currently, nesting sites are more numerous and widespread. Most of the pairs are concentrated in the central-eastern part of the city, where ancient buildings with holes and cavities are more abundant.

Interactions with wildlife

In Genoa, interspecific competition behaviors for nesting sites have been recorded only with the Urban Pigeon *Columba livia* var. *domestica* and the Jackdaw.

Interactions with humans

From the impressions and statements expressed by a hundred citizens, both inhabitants of the center and of the peripheral areas of Genoa, a rather singular fact emerged: at least a quarter of them declared that they were not aware of the presence of parakeets in the city. Of the other people interviewed, some Genoese citizens appreciate the presence of the Rose-ringed Parakeet for aesthetic-recreational reasons, whereas many of them consider these animals an annoying source of noise and carriers of diseases such as psittacosis, as well as a cause of filth of cars and roads. Moreover, it was found that the parakeets currently frequent the countryside surrounding the town of Genoa, representing sometimes a source of disturbance for small farmers. However, it was also observed that Genoese parakeets still tend to avoid direct contact with humans and rarely forage in private gardens if these are frequentely attended by owners or closely surrounded by houses, even if rich of fruit trees.

During the study period, damage to fruit trees was recorded in various parts of the city, mainly in the Albaro district: to avoid attacks on plants by parrakeets, some people tried to keep them away by installing bollards made with aluminum sheets, however without success. The heaviest damages were recorded in the vegetable gardens on the heights of the central (S. Ratto, pers. com.) and eastern part of the city. In spring-summer 2016, for example, residents of an eastern district reported attacks by parakeets on fruit trees and on peas (of which they are very greedy), broad beans, green beans, salads, etc. A similar scenario was recorded in Val Polcevera

Table 2. Plant species on which Rose-ringed Parakeets are known to feed in Genoa and their parts used as food sources (ordered by Scientific name). Where not indicated, data were obtained in the framework of the present study.

Scientific name	Trophic resource used	Source
Actinidia deliciosa	Fruits	
Aesculus hippocastanum	Buds, Flowers and Fruits	
Ailanthus altissima	Flowers and Seeds	
Celtis australis	Seeds	
Cercis siliquastrum	Flowers and Seeds	
Chamaerops humilis	Fruits	Maranini & Galuppo 1994
Citrus aurantium	Fruits	
Corylus avellana	Fruits	
Cupressus arizonica	Seeds	Vergano 1998
Cupressus sempervirens	Seeds	
Diospyros kaki	Fruits	Spanò & Truffi 1986
Eriobotrya japonica	Fruits	
Ficus carica	Fruits	
Juglans regia	Seeds	Vergano 1998
Laurus nobilis	Fruits	Maranini & Galuppo 1994
Ligustrum lucidum	Seeds	Vergano 1998
Magnolia grandiflora	Seeds	
Paulownia tomentosa	Seeds	Vergano 1998
Phoenix canariensis	Flowers and Fruits	
Pinus pinaster	Needles (fresh or not)	
Pisum sativum	Seeds and Pods	
Platanus acerifolia	Seeds and Buds	
Prunus armeniaca	Flowers	Vergano 1998
Prunus avium	Flowers and Fruits	
Prunus domestica	Fruits	
Prunus dulcis	Fruits	Spanò & Truffi 1986
Prunus spinosa	Fruits	
Pyrus communis	Fruits	Vergano 1998
Quercus ilex	Fruits	Maranini & Galuppo 1994
Robinia pseudoacacia	Flowers and Seeds	
Sequoia sempervirens	Seeds	Vergano 1998
Sophora japonica	Flowers and Seeds	
Taxus baccata	Fruits	Maranini & Galuppo 1994
Ulmus minor	Seeds	
Vitis vinifera	Fruits	
Washingtonia robusta	Flowers and Fruits	

and Val Bisagno: during the spring 2017 there was an attack on peach trees still in bloom, despite they were protected by plastic nets. The protection was not enough because the parakeets, thanks to their powerful bill, were able to break quickly the nets.

DISCUSSION

The survey shows that the population of the Rose-ringed Parakeet in Genoa stands at about 650 individuals, distributed throughout the territory during daytime and with few community evening roosts. The Genoese range of the species has widened compared to the 1970s (Spanò & Truffi 1986). Parallel to the more widespread exploitation of the territory, the spectrum of botanical essences used for food has also expanded (see Maranini & Galuppo 1994 and Vergano 1998) coming to include at least 36 species.

During the study period, the roosts changed several times. It is hard to hypothesize the underlying causes of this variation but they could be related to climatic features, and in particular to daily temperatures, as demonstrated for the Starling *Sturnus vulgaris* by Heisterberg et al. (1984).

It is well known that the Rose-ringed Parakeet strongly compete with native species, not only birds, both in terms of exploitation of nesting sites and trophic resources, as documented in several countries (Strubbe & Matthysen 2007; Kumschick & Nentwig 2010; Strubbe 2010; Hernandez-Brito et al. 2014; Menchetti et al. 2014; Hernandez-Brito et al. 2018). However, since most of the Genoese individuals spend their time only within the borders of the city, competition with native species charachterized by similar feeding habits and nesting behaviour is rare. In fact, species like woodpeckers and the Hoopoe *Upupa epops* are much less abundant in the city than on the wooded hills and, for now, are not likely to be impacted by the expansion of this invasive alien bird. Moreover, the preference shown in Genoa by parakeets for nesting sites located high on buildings could be a valid explanation for the lack of competition we recorded, unlike what found in other cases, for example by Orchan et al. (2013) for the Syrian Woodpecker *Dendrocopos syriacus* and by Dodaro & Battisti (2014) for the Starling . Interspecific competition behaviors for nesting sites have been recorded only with species that in Genoa use the cavities in the walls or in the buildings for nesting, namely the domestic Urban Pigeon and the Jackdaw, which have no conservation issues. Competition occurred in the case of cavities with a fairly large entrance, although the Rose-ringed Parakeet generally prefers holes with smaller entrances, more suited to its size. Jackdaws have been seen several times entering the holes occupied by parakeets, perhaps for predatory purposes on eggs or nestlings, but generally parakeets were able to drive away intruders, in some cases mobbing them with the help of neighbors. Finally, we can hypothesize a competition with the Swift *Apus apus* and the Pale Swift *Apus pallidus* for the holes under the eaves or the roof projections, similarly to what Grandi et al. (2018) observed in the city of Pavia (Lombardy, Northern Italy). It is possible that, up to now, such an interaction has not been recorded due to the still small parakeet population.

Based on the results of our study, at the moment the Rose-ringed Parakeet does not seem to represent a serious problem in the city of Genoa. The socio-economic impacts recorded, in fact, arise mainly from foraging in small private gardens and the neighbouring farmland areas have been, to date, only marginally interested.

Obviously, the approach of people to the presence of parakeets (appreciation vs aversion) is directly and heavily influenced by their own experience. Owners of the gardens where the birds feed, of the cars parked under the roosts or of the houses that directly overlook the roost, for example, see them in a decidedly negative way. On the contrary, users of urban parks or those citizens not directly damaged by parakeet activities, generally appreciate them. The parakeets, actually, can represent a problem due to their loud and shrill calls, especially for the citizens who reside close to the roosts. At dusk and dawn, when the parakeets gather or move away

from the roost, the noise of about 500 individuals concentrated in a small patch of the city can be very annoying (Mori et al. 2020). The ecological impacts in Genoa are also limited: the Rose-ringed Parakeet currently does not represent an evident threat to native species.

Our research highlighted that in the last 40 years the Genoese population of Rose-ringed Parakeet has undergone a considerable growth, resulting still increasing, both in terms of numbers and of range, expanding more and more both towards the innermost areas of the Val Bisagno and Val Polcevera, and along the coast. This population dynamic in the city of Genoa resembles that recorded in other European cities such as London, Paris and Brussels (Butler 2003; Clergeau et al. 2009). If the climatic and environmental conditions will remain favorable for the species, a consistent growth is to be expected for the Genoese population as well. This could represent a problem, since the parakeets would be able to reach areas devoted to agriculture, where they could have significant economic impact, and/or could compete with native fauna (birds in particular), much more abundant in the rural areas than in the city. At the beginning of 2021, this issue prompted the municipality of Genoa to undertake a citizen science study still in progress with the purpose to update the data on Rose-ringed Parakeet and consequently evaluate which management measures should be adopted in the future to control this potentially invasive alien species (Ferretti et al. – submitted).

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