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Paper

Census and Control of Columba livia var. domestica in Genoa, Italy: Trends in the Higher-Central District (2010–2017)

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Abstract

Urban pigeon populations pose significant challenges in cities worldwide, contributing to structural damage, health concerns, and environmental imbalances. Since 2005, the Municipality of Genoa has implemented a targeted pigeon control programme utilising Nicarbazin, a sterilising agent that inhibits egg fertilisation. This study assesses the effectiveness of the sterilisation strategy in the Circonvallazione a Monte district from 2010 to 2017, analysing population trends and behavioural responses across various feeding points. Using a combination of statistical methods, including Duncan's test, ANOVA, and time series analysis, we identify significant declines in pigeon numbers and the emergence of distinct population dynamic patterns. Results indicate that while pharmacological sterilisation effectively reduces populations, its success varies depending on local environmental factors, nesting availability, and unauthorised feeding. The study suggests that an integrated approach, combining reproductive control with habitat modification and public awareness initiatives, is essential for long-term pigeon population management. Our findings contribute to the growing body of research on humane and sustainable urban wildlife control.

Keywords

Columba livia var. domestica, pigeon management, ANOVA, urban ecology, Nicarbazin, population control

Introduction

Urban pigeon populations have been increasing globally, raising concerns about their impact on public health, infrastructure, and biodiversity (Haag-Wackernagel & Moch, 2004; Albonetti *et al.*, 2025). Pigeons are highly adaptable to urban environments, exploiting food sources provided by human activities and utilising buildings as nesting sites (Johnston & Janiga, 1995). However, their presence can lead to public and private property damage, the transmission of zoonotic diseases such as ornithosis and cryptococcosis, and related sanitation issues (Haag-Wackernagel, 2005; Albonetti et al., 2025). Consequently, managing pigeon populations in urban areas is an essential component of integrated pest control strategies. Traditional pigeon control measures, such as trapping, culling, and chemical repellents, have proven to be ineffective or controversial due to ethical and logistical constraints (Giunchi et al., 2012; Albonetti et al., 2025). In response, non-lethal methods, including habitat modification, public awareness campaigns, and reproductive control, have gained traction as more sustainable and humane alternatives (Jerolmack, 2008). Pharmacological sterilisation using Nicarbazin, a compound that inhibits egg fertilisation, has emerged as a viable strategy to limit pigeon population growth while avoiding direct harm to the birds (Avery et al., 2008; Albonetti et al., 2015; Albonetti et al., 2025). The city of Genoa, Italy, started a pigeon containment program in 2005, employing

Nicarbazin-treated corn to regulate population size. Initially, the program targeted the “Foce” district but was later expanded to the “Circonvallazione a Monte” district in 2010, due to the presence of large pigeon colonies in higher-central urban areas. This district is characterised by a diverse range of habitats, including parks, historical buildings, and high-density residential areas, making it an ideal location for assessing the efficacy of reproductive control measures. This study aims to evaluate the long-term effectiveness of the sterilisation program in the Circonvallazione a Monte district from 2010 to 2017. By analysing population trends, spatial distribution, and the impact of environmental factors, we seek to determine whether Nicarbazin administration provides a sustainable solution for urban pigeon management. The findings of this research will contribute to the broader debate on ethical and effective urban wildlife control and will address possible future management policies.

Matherials and methods

Containment plan

The Municipality of Genoa has been carrying out a containment plan for the urban population of*Columba livia* var. *domestica* since 2005, still ongoing. The project includes the administration of a veterinary drug (Nicarbazin 0,8 g/kg) in the form of corn grains, distributed according to the guidelines established by the manufacturing company (Albonetti et al., 2015), in specific places, the details of which are listed below, called “feeding points”. This eight-year project has made it possible to observe the long-term dynamics of the colonies in which the sterilizing plan is active.

Study Area

The study was performed over the period from 2010 to 2017, focusing on Circonvallazione a Monte, a district spanning approximately 3.4 km^2 with altitudes ranging from sea level to 400 metres. Feeding points were strategically selected in green areas and public gardens to minimize human-wildlife conflict while maximizing sterilization effectiveness.

The city of Genoa has a unique orographic structure, characterized by a rapid increase in elevation from the coastline to the higher central district (indicated by the red circle in Figure 1). To sterilize the largest pigeon colonies in both the lower and higher central districts, it was necessary to expand the existing sterilization program—active since 2005 in the coastal district of Foce (Albonetti et al., 2015; green area in Figure 2)—to the higher central districts known as the “Circonvallazione a Monte” (Figure 2).

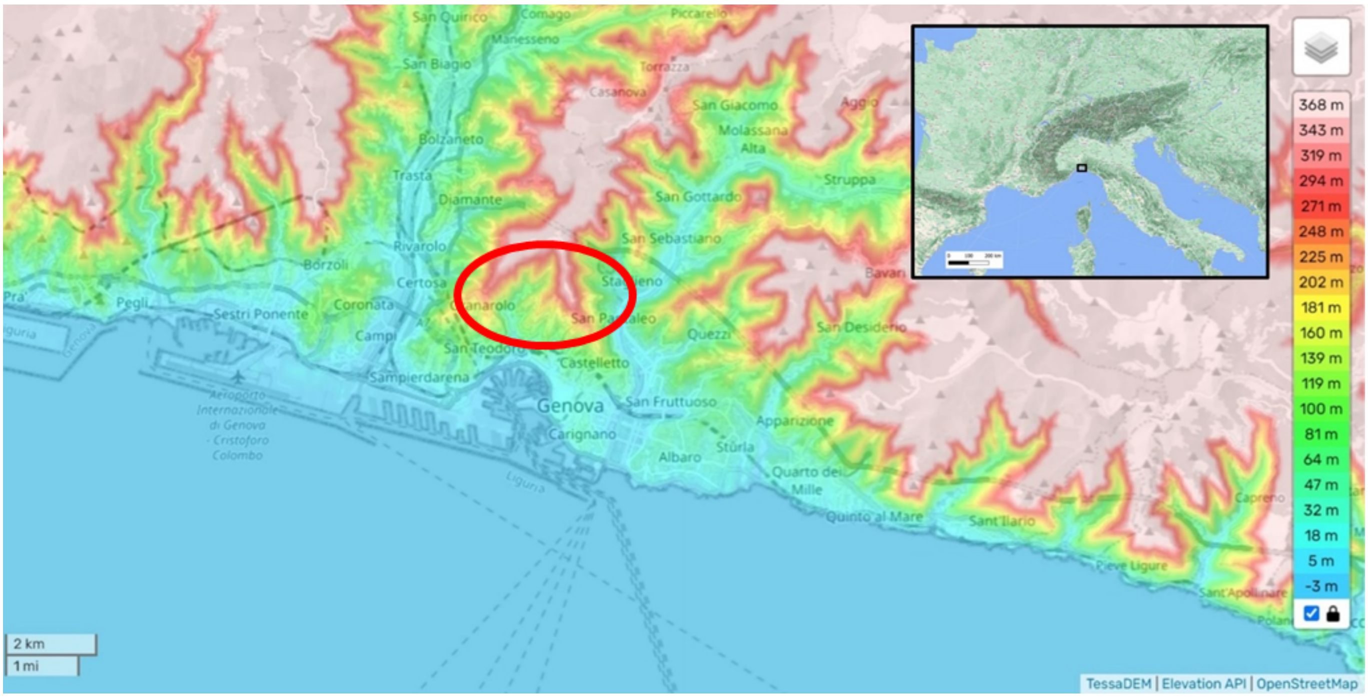

Figure 1. Altitude map of the city of Genoa – OpenStreetMap

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Feeding points selection and monitoring

We selected ten feeding points based on an analysis of environmental factors influenced by the territorial, eco-ethological, and social characteristics of the city. These factors included the presence of trophic sources (such as food, urban waste, and water), unauthorized pigeon feeding by citizens, buildings with architectural features suitable for resting or nesting, the presence of tall trees as nesting sites, and reports of discomfort from residents. The Circonvallazione a Monte district, particularly along the road network extending from Corso Monte Grappa to Via Paleocapa (Figure 2), exhibits all these critical factors. Another selection criterion was the safety and accessibility of the sites for drug administration. The control plan was implemented at ten carefully selected feeding points (Figure 2) through the daily work of naturalists and biologists, conducted from Monday to Friday. The identification of these ten feeding points was designed to create a continuous pathway extending from the coastline (Foce coastal district) to an elevation of 400 meters above sea level (higher central district). This area encompasses the city centre of Genoa, covering approximately 3.4 km^2. In relation to the total built-up area of Genoa—around 50 km^2 out of the city's 240 km^2 municipal area (link 1)—this represents approximately 7% of the city's inhabited territory.

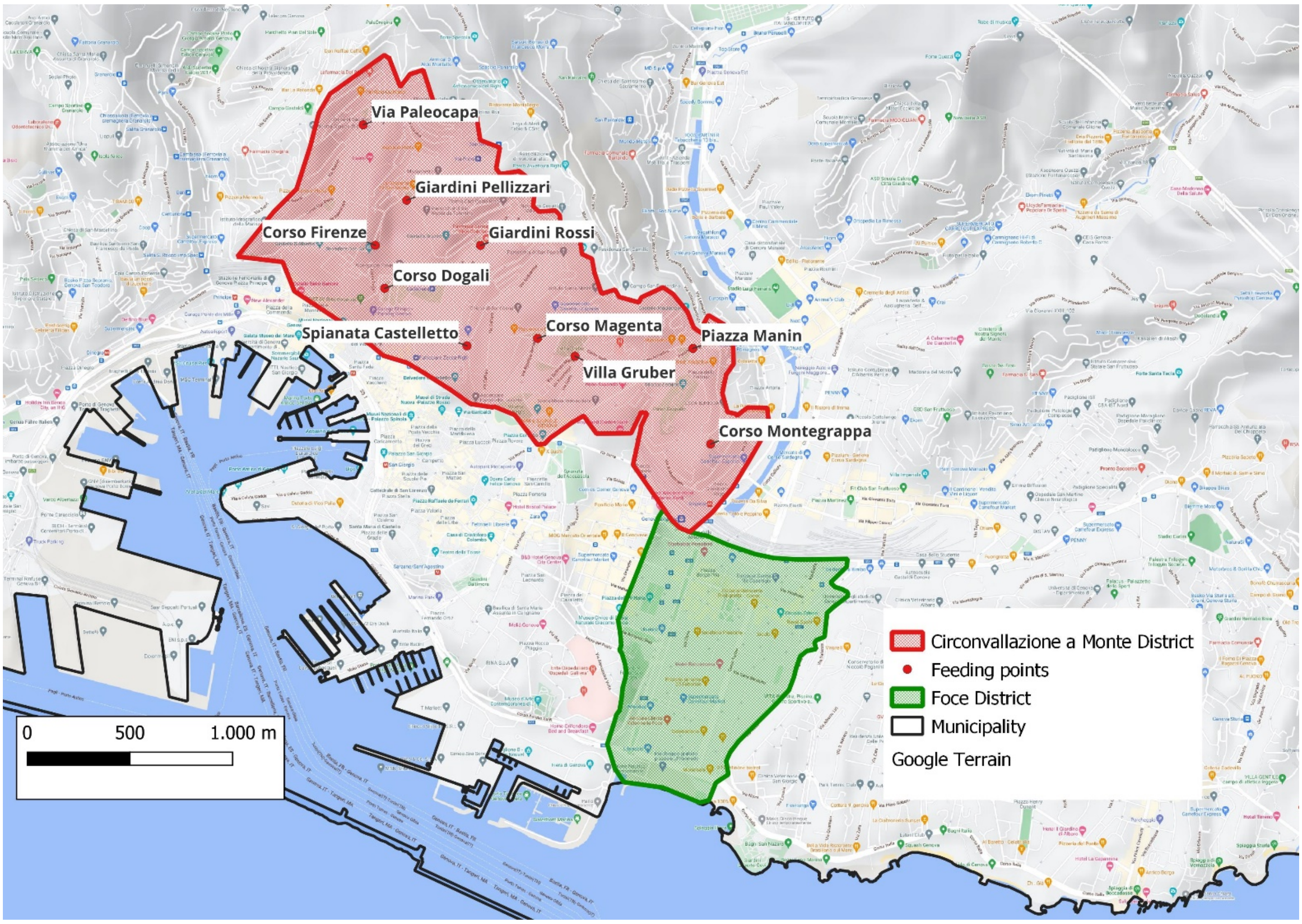

Figure 2. Map of the centre of Genoa. The surface of the Foce Area is approximately 1 km2 while the surface of the Monte Circonvallazione Area is approximately 2.4 km2.

The selection of feeding points was based on areas deemed suitable for the safe distribution of the sterilising drug, ensuring the safety of both humans and animals, in accordance with the guidelines provided by the manufacturing company. For these reasons, we primarily selected gardens and green spaces that already hosted pigeon colonies, offering shelter or separation from vehicular traffic, and distancing them from the intense human activity characteristic of this central district. Below is a summary of the key factors that influenced the choice of feeding points, categorised by area (Table 1):

Corso Monte Grappa: Located near Giardini Palatucci (gardens), this site hosted a pre-existing pigeon colony that was regularly fed by a local resident. The presence of water and tall trees further supported the colony, leading to conflicts with nearby residents.

Piazza Manin: Despite constant vehicular traffic, this square was frequented by citizens who regularly fed the local pigeons. The birds found favourable nesting sites in the numerous trees and benefited from two consistent water sources.

Villa Gruber: A tree-lined urban garden within an ancient noble villa, designed for recreational activities. Trophic sources were readily available due to numerous citizens feeding the resident pigeon colony, either intentionally or unintentionally.

Giardini Pellizzari & Corso Magenta: Although these two gardens lacked unauthorised feeding, their abundance of potential nesting sites—such as trees, architectural niches, and ravines—made them attractive to pigeons from neighbouring areas. Recently, new food shops contributed to the unintended availability of food.

Spianata Castelletto: A scenic overlook with large flowerbeds and a moderate yet consistent pigeon presence. The birds found food from numerous nearby shops and visiting tourists.

Giardini Rossi: The environmental characteristics of this garden closely resembled those of Giardini Pellizzari, Corso Magenta (with numerous potential nesting sites), and Villa Gruber (with ample trophic sources).

Corso Firenze: Its elevated position, relative to Corso Dogali, made it an ideal location for intercepting pigeon colonies from surrounding streets and areas. The presence of buildings and trees at the perimeter provided favourable conditions for roosting and nesting.

Via Paleocapa: Pigeons here benefited from a row of trees, water sources, and unauthorised feeding by some residents, even within private homes. These factors contributed to ongoing challenges in pigeon-human coexistence over the years.

Corso Dogali: Originally the most problematic site in the Circonvallazione a Monte district, this location housed the city's largest pigeon colony. The area was characterised by abundant roosting and nesting sites, including trees and buildings, ahigh number of unauthorised feeders, and numerous water sources, attracting pigeons even from distant areas.

Street/Place	Food/water	Unauthorised feeding	Favourable architectural features	Presence of tall trees	Citizens' discomfort
Corso Monte Grappa (Giard. G. Palatucci)	X	X		X	X
Piazza Manin	X	X		X	X
Villa Gruber	X			X	
Corso Magenta	X	X	X	X	X
Spianata Castelletto	X		X	X	
Corso Firenze	X		X	X	X
Giardini Rossi	X		X	X	X
Giardini Pellizzari	X		X	X	
Via Paleocapa	X	X	X	X	X
Corso Dogali		X		X	X

Table 1. Synthesis of the environmental, eco-ethological and social characteristics of each feeding point selected.

Data Collection and Statistical Analysis

A daily pigeon census was conducted using the point count technique (Bibby et al., 1992) by trained biologists and naturalists under the direct supervision of technicians from the Genoa Municipality. Data collection for the Circonvallazione a Monte district began in 2010, and for this study, data from the period 2010–2017 were analysed. Statistical processing was carried out using SAS software in collaboration with the Department of Mathematics at the University of Genoa. For each feeding point, a table is provided summarising key statistical indices, including year, number of observations, minimum, median, maximum, and mean pigeon counts. Additionally, annual boxplots and population trends are presented (Appendix 2). To evaluate the consistency of population trends across colonies, we compared the mean annual pigeon counts for each year using Duncan's test (Appendix 1) and Analysis of Variance (ANOVA) (Appendix 2). Thematic maps were generated using QGIS software.

Results

In this section we summarised the statistical analyses of trends in pigeon mean numbers over the period 2010-2017. The complete report for each analysis is listed in Appendices 1 and 2.

Population trends and Decline Patterns

Figure 3. Time series and trend of monthly mean values for feeding points with decrease > 45%.

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The annual mean pigeon population trend, as observed in the graphs and ANOVA results, is not consistent across all feeding points. A significant decrease in the mean annual number of pigeons is particularly evident at Corso Monte Grappa, Piazza Manin, Spianata Castelletto, Corso Firenze, Via Paleocapa, and Corso Dogali, where the percentage variation in the mean annual pigeon count between 2010 and 2017 exceeds 45%. Table 2 highlights these substantial declines, with the most pronounced decrease recorded at Corso Dogali, where the maximum peak has dropped by 86.8%. Figure 3 (time series) presents the monthly mean value trends for the six aforementioned zones.

Feeding point	Percentage decrease 2010-2017
Corso Monte Grappa (Giard. G.Palatucci)	-66.2
Piazza Manin	-57.2
Spianata Castelletto	-65.0
Corso Firenze	-47.6
Via Paleocapa	-53.1
Corso Dogali	-86.8

Table 2. Summary of decreases > 45%

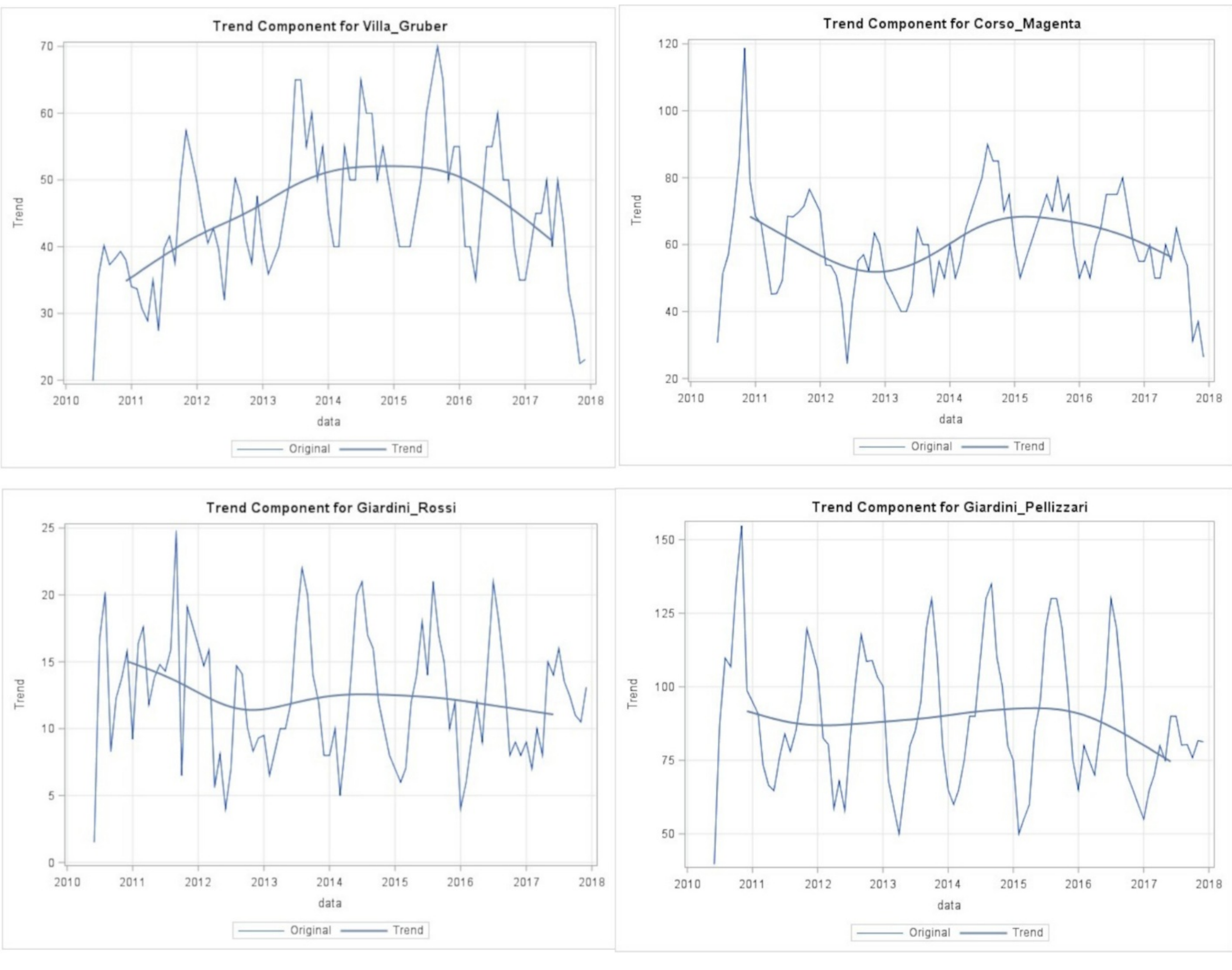

Figure 4. Time series and trend of monthly mean values for feeding points with decrease < 45%.

Smaller decreases (<45%) occurred at Villa Gruber, Corso Magenta, Giardini Rossi, and Giardini Pellizzari (Table 3), where the percentage differences are smaller than those of the other feeding points; time series in these cases does not show the same trend (Figure 4).

Feeding point	Percentage of decrease 2010-2017
Villa Gruber	-6.3
Corso Magenta	-34.4
Giardini Rossi	-4.4
Giardini Pellizzari	-23.2

Table 3. summary of decreases < 45%.

Identified Patterns

ANOVA confirmed significant differences in annual means ($p<0.001$), while Duncan's test indicated non-random decreases in the pigeon populations. Two distinct population trends were identified:

Pattern 1: A four-phase decline consisting of:

Magnet effect (Albonetti et al., 2015) – a sub-annual phase characterized by an increase in the number of pigeons attracted to the feeding point (Sudden increase in the number of pigeons attracted to an area; it may occur following the establishment of a new feeding point.).

First decline phase – a noticeable decrease in the daily mean number of pigeons.

Plateau phase – a stable period with a sub-horizontal trend in pigeon counts.

Second decline phase – a renewed decrease in the mean number of pigeons.

This pattern, observed at most feeding points—including Corso Dogali and Villa Gruber (though less pronounced) is illustrated in Figure 5.

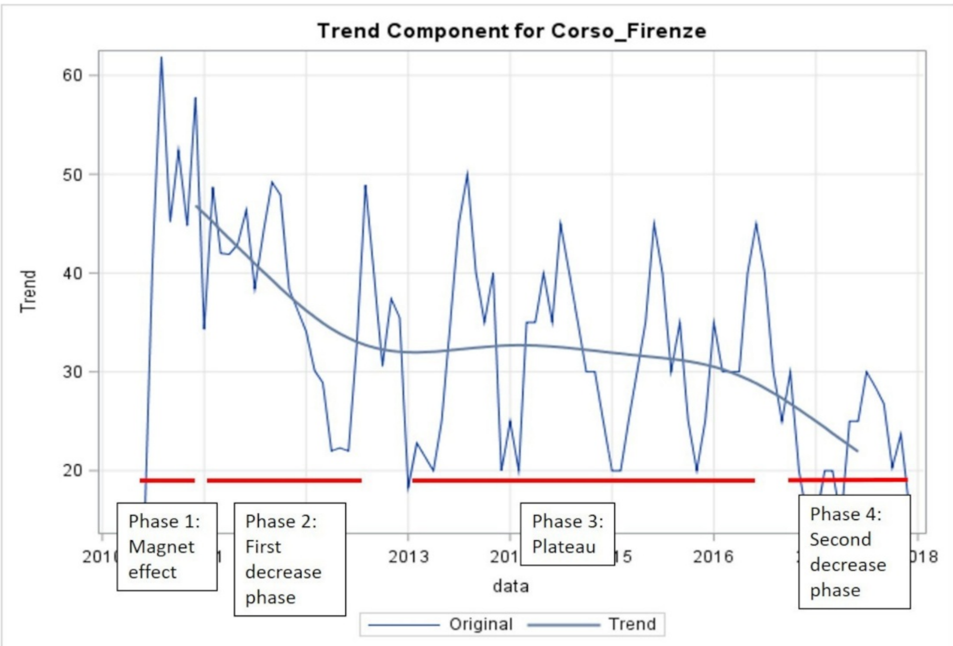

Figure 5. Pattern 1

Pattern 2: A bell-shaped trend, characterized by a multi-year magnet effect, followed by a single decline phase (Figure

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6). This pattern may correspond to the first two phases of Pattern 1 but it develops at a slower rate.

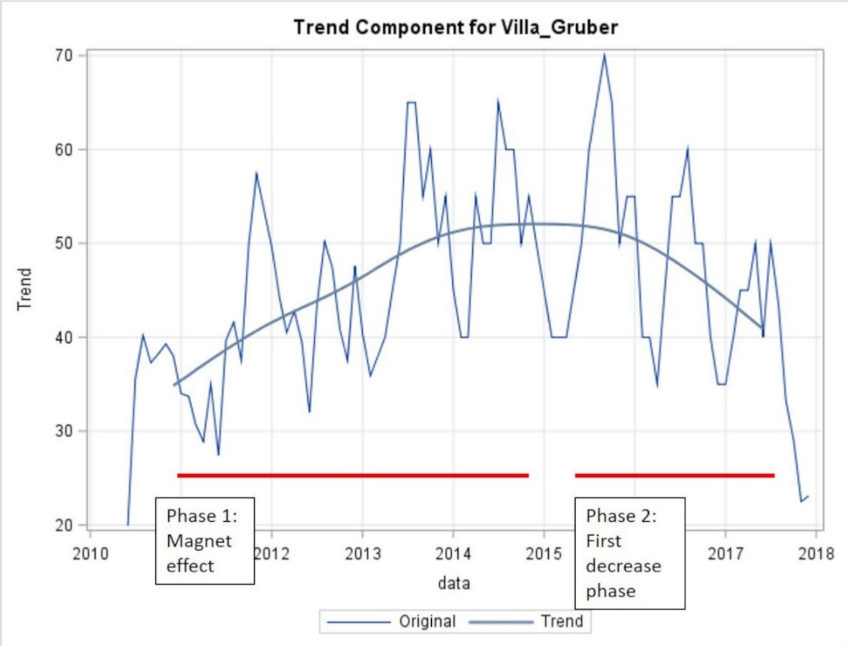

Figure 6. Pattern 2.

The statistical significance of patterns and, more generally, of trends in the number of pigeons observed at the different feeding points was tested by means of Duncan's tests (Appendix 1) and ANOVA (Appendix 2). The interpretation of the results of Duncan's tests requires the assumption that the annual means marked with the same colour (e.g. red, blue, green, etc.) are not significantly different. For example, for Piazza Manin (Figure 7), years 2010, 2011, 2012, and 2013 (blue colour) and years 2014, 2015, 2016, and 2017 (red colour) cannot be considered to be similar.

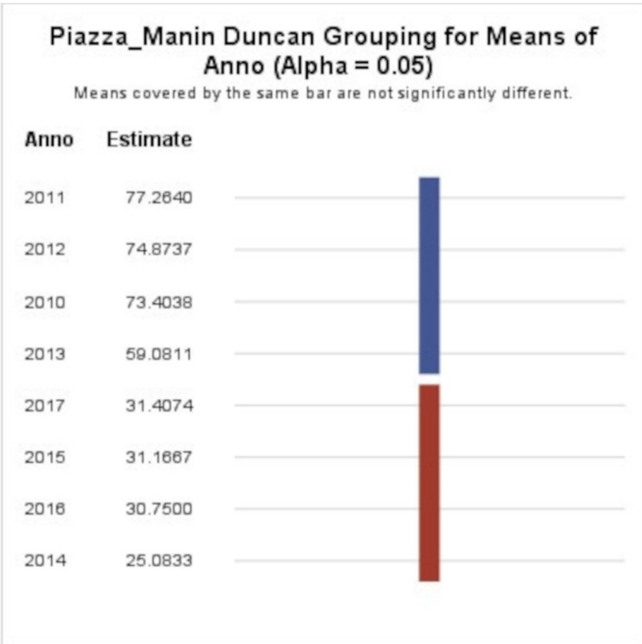

Figure 7. Duncan's test for Piazza Manin.

The results of Duncan's test for annual means (Appendix 1) confirmed the findings from descriptive statistics and their percentage differences (Table 4) across the feeding points Corso Monte Grappa, Piazza Manin, Spianata Castelletto, Corso Firenze, and Corso Dogali. However, no consistent pattern was observed for Via Paleocapa. The test analysis enable us to distinguish and group the years of the first protocol period (2010–2013) separately from those of the final period of activity (2015–2017), revealing a statistically significant difference between these two time intervals.

Additionally, using analysis of variance (ANOVA), we tested whether the annual means from 2010 to 2017 were comparable for each feeding point. The results (Appendix 2) indicate that the hypothesis of mean equality should be rejected, as the p-values for all feeding points are close to 0, confirming significant differences across years.

Year/Feeding point mean	Corso Monte G rappa	Piazza Manin	Villa Gruber	Corso Magenta	Spianata Castelletto	Giardini Rossi	Giardini Pellizzari	Corso Firenze	Via Paleocapa	Corso Dogali
2010	31.7	72.8	35.5	70.3	31.0	12.7	104.4	45.4	61.7	486.1
2011	30.6	79.8	37.8	62.3	31.3	14.9	84.5	43.1	42.2	502.0
2012	30.7	71.9	43.0	52.1	24.8	10.7	89.7	32.0	25.0	577.9
2013	27.4	41.2	51.0	50.6	22.9	12.9	89.4	31.9	33.0	426.6
2014	25.6	25.1	51.7	71.7	20.8	12.5	92.5	32.9	35.4	320.8
2015	23.9	31.2	52.1	65.8	24.0	12.8	91.3	29.2	31.7	250.0
2016	21.8	30.8	46.7	64.2	16.0	11.1	85.0	30.8	30.8	131.7
2017	10.8	30.5	38.1	50.1	10.5	11.6	77.0	22.1	28.5	61.3
Mean	24.9	46.2	45.0	60.5	22.1	12.3	88.4	32.7	33.0	333.9

Table 4. Summary of annual mean values.

The following maps, created using QGIS software (Figure 8 and 9), illustrate population differences through a color-coded system based on the maximum mean number of pigeons recorded in the first year of feeding (Corso Dogali: 486.1). The objective is to highlight variations in the annual mean pigeon counts (Table 4).

Larger colonies are represented by dark red, indicating values exceeding 50% of the maximum annual mean recorded in 2010 (the start of data collection, with Corso Dogali as the reference).

Smaller colonies are shown in green, corresponding to values below the minimum mean recorded in 2010 (observed at Giardini Rossi).

Intermediate values are depicted in yellow-orange shades, representing populations between these two extremes.

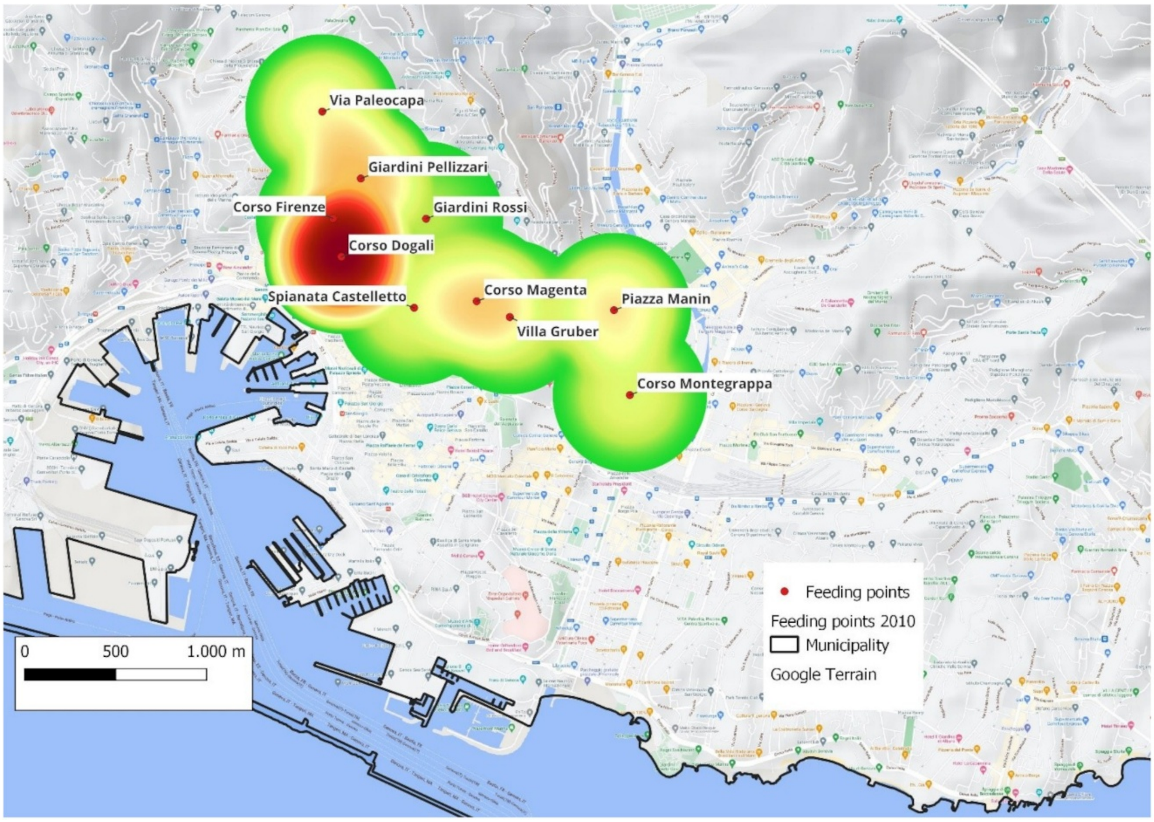

Figure 8. Map of Columba livia var. domestica presence in 2010.

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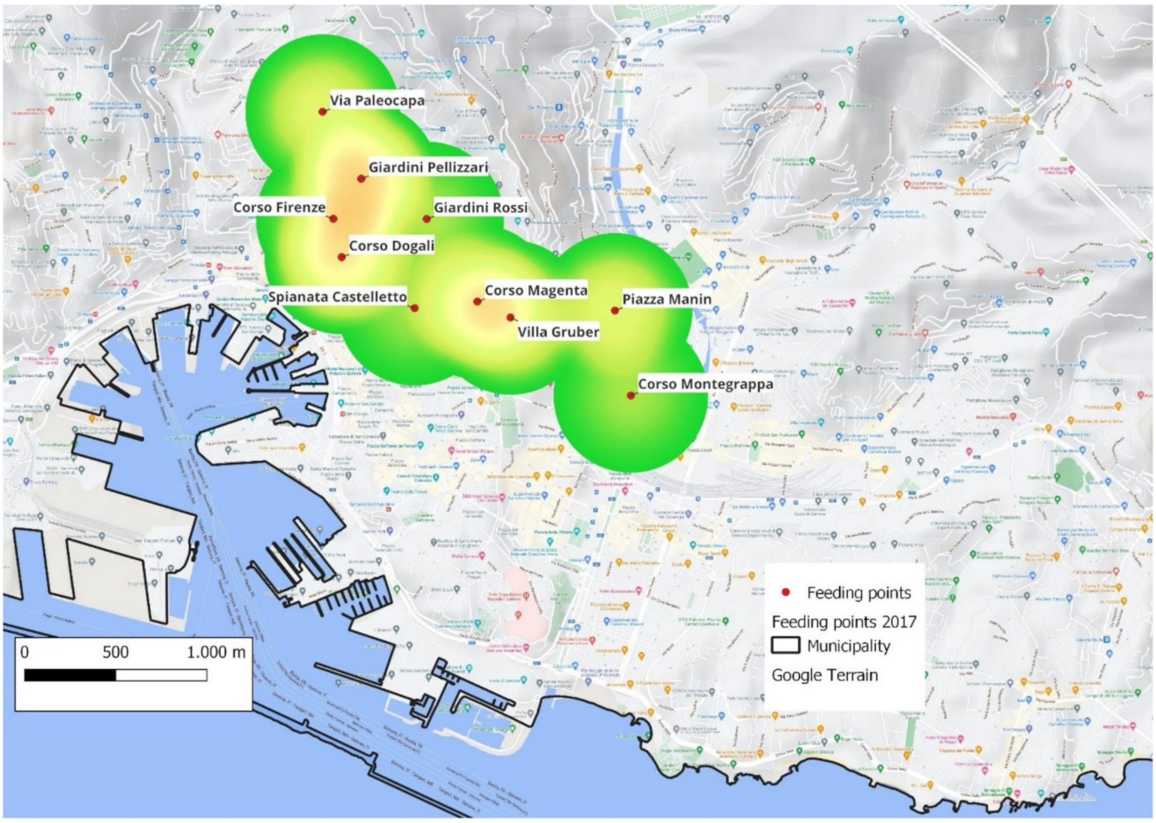

Figure 9. Map of Columba livia var. domestica presence in 2017.

Discussion

The findings indicate that pharmacological sterilization via Nicarbazin is an effective tool for pigeon population control in urban settings. Throughout the study period, trends in pigeon populations at nearly all feeding points indicate a consistent decline in the annual mean number of pigeons, a pattern confirmed by statistical analyses. In some cases, the observed percentage decreases exceed those recorded in the Foce district between 2005 and 2015 (Albonetti et al., 2015), demonstrating a significant reduction in pigeon numbers. Moreover, the decline follows at least one distinct and identifiable pattern rather than occurring randomly. The observed decrease aligns with similar studies conducted in other European cities, demonstrating the reliability of controlled feeding as a non-lethal management strategy (Giunchi et al., 2012; Haag-Wackernagel, 2005).

Population Decline Trends and Influencing Factors

Based on Duncan's test analysis (Appendix 1) and ANOVA results (Appendix 2), it is evident that the percentage decreases and variations in annual mean pigeon numbers are not random, but instead follow a clear, recognisable trend at key locations such as Corso Monte Grappa, Piazza Manin, Spianata Castelletto, Corso Firenze, and Corso Dogali. This trend can be summarised into the following four distinct phases, identifiable by their numerical progression and supra-seasonal duration:

Magnet Period – An initial phase characterized by an increase in pigeons attracted to the feeding site.

First Phase of Decrease – A noticeable decline in pigeon numbers as the population begins to adjust.

Plateau of Stability – A temporary stabilization in the population trend.

Second Phase of Decrease – A further reduction in pigeon numbers, continuing the overall decline.

Across all feeding points, a consistent and dynamic decrease in pigeon populations has been observed, with the most pronounced reduction exceeding 86% at Corso Dogali. In contrast, at locations where the decline has been less pronounced—such as Villa Gruber, Corso Magenta, Giardini Rossi, and Giardini Pellizzari—it is likely that the rate of reduction is influenced by site-specific ecological, environmental, and social factors. These factors may delay the transition to the plateau and second phase of decrease, suggesting that variations in local conditions can alter the effectiveness and speed of the sterilisation protocol.

It is also reasonable to predict that, without targeted interventions to address these influencing factors, the second phase of decrease is unlikely to lead to the complete extinction of local pigeon colonies. Instead, it may stabilise at a minimum threshold, corresponding to the inverse of the carrying capacity of the urban system (Hui, 2006). This suggests that pharmacological sterilization alone may not be sufficient to reduce pigeon populations beyond a certain limit.

However, variation in decline rates across feeding points suggests additional factors influencing population dynamics. Areas with abundant nesting sites and unauthorized feeding exhibited slower reductions, implying that sterilization alone may not be sufficient in certain locations. This aligns with findings from other cities, where accessibility to alternative food sources and citizen feeding behaviours influenced the effectiveness of reproductive control measures (Dobeic et al., 2011).

The observed decline in pigeon populations varied significantly across different feeding sites, influenced by factors such as food availability, nesting opportunities, and human intervention.

High Decrease Rates: Locations such as Corso Dogali and Corso Monte Grappa exhibited marked population declines, likely due to the isolated nature of their feeding points and scarcity of alternative food sources. In these areas, pigeons relied almost exclusively on the designated feeding points, making them more vulnerable to population reductions when food availability decreased. The lack of nearby urban food sources, such as public squares or markets, further contributed to the steep decline.

Lower Decrease Rates: In contrast, sites such as Villa Gruber and Giardini Rossi experienced a more gradual decline in pigeon numbers. This slower reduction can likely be attributed to the presence of abundant nesting areas, which provided a degree of stability to the local pigeon populations. Additionally, unauthorised feeding by residents or visitors may have played a role in sustaining these colonies, preventing a rapid decrease in numbers. The availability of alternative food sources in nearby parks or urban areas could also explain the more moderate decline observed at these sites.

Carrying Capacity Limits: While a significant reduction in pigeon numbers was observed across most feeding points, the decline did not continue indefinitely. Instead, the population appeared to stabilise at a minimum threshold, suggesting that the ecosystem may have reached a carrying capacity limit. This stabilization indicates that despite food restrictions, a residual population persists, potentially sustained by alternative resources such as urban waste, spontaneous feeding, or the presence of well-established roosting and nesting sites. The plateauing trend highlights the need for complementary management strategies, such as habitat modification, public awareness campaigns, or stricter enforcement of feeding regulations, to ensure a more effective and sustainable approach to pigeon population control.

Overall, these findings emphasize the importance of considering multiple environmental and anthropogenic factors when assessing urban pigeon population trends. Future interventions should take into account both food availability and habitat conditions to design more targeted and effective management strategies.

Comparative Insights and Recommended Management Strategies

A comparison of our findings with other urban pigeon control programs highlights the importance of a multi-pronged approach to achieving long-term, sustainable population management. Cities that have successfully controlled pigeon populations have combined multiple strategies, integrating food control, habitat modification, public education, and continuous monitoring. Based on our results and insights from previous research, we recommend the following measures:

Expansion of Controlled Feeding Areas

Increasing the number of designated feeding stations with Nicarbazin-treated food could significantly enhance the effectiveness of population control efforts. Similar strategies have proven successful in cities such as Basel and Barcelona, where the targeted distribution of treated food led to a notable reduction in pigeon fertility and overall population size (Haag-Wackernagel & Moch, 2004; Senar et al., 2017). By expanding controlled feeding zones, authorities can better regulate food intake while minimising uncontrolled feeding by the public, which remains a major challenge in urban settings.

Public Awareness Campaigns

Raising awareness among residents about the negative consequences of unauthorised pigeon feeding is crucial for limiting alternative food sources that sustain urban pigeon populations. Studies in London and Paris have shown that public feeding bans alone are insufficient unless accompanied by educational campaigns that inform citizens about the ecological and health risks associated with uncontrolled feeding (Dobeic et al., 2011). Engaging the public through signage, community outreach programmes, and media campaigns can foster greater compliance with regulations and reduce unintentional population support.

Urban Habitat Modification

Modifications such as anti-roosting spikes, sloped ledges, and netting can limit nesting opportunities, reducing population growth without relying solely on fertility control measures. Integrating pigeon-deterrent designs into new building regulations and urban planning can provide a long-term, passive management solution that minimises the need for continuous human intervention.

Sustained Monitoring and Adaptive Management

A long-term monitoring framework is essential to assess the effectiveness of pigeon control programmes and make necessary adjustments over time. Regular population surveys combined with periodic evaluation of sterilisation strategies can help prevent population rebounds and ensure that intervention measures remain effective. In urban pigeon management, adaptive approaches—where strategies evolve based on real-time data—have been instrumental in maintaining stable pigeon populations (Fitzwater, 1988). Cities that have successfully controlled pigeon numbers have implemented data-driven decision-making, allowing authorities to respond to changing urban dynamics and optimize resource allocation for population control efforts.

A major challenge in long-term pigeon population control is maintaining consistent programme effectiveness. Studies indicate that stopping or reducing sterilisation efforts can lead to rapid rebounds in population numbers (Fitzwater, 1988). Therefore, ongoing management strategies must integrate pharmacological sterilisation with complementary measures, such as reducing available food sources, modifying urban landscapes to limit nesting sites, and increasing public awareness campaigns (Albonetti et al., 2025).

Conclusion

The sterilisation plan has significantly reduced pigeon populations in Genoa's Circonvallazione a Monte district. The results suggest that while Nicarbazin is highly effective in a long-term scenario, success in pigeon population control could be enhanced through integrated urban wildlife management strategies. Given the findings of this study, it is recommended that sterilisation programmes be complemented by additional measures within an integrated ecosystem management approach. In feeding points or areas characterised by complex environmental and anthropogenic conditions, it is crucial to address the underlying factors that could undermine the success of the sterilisation plan. Synergistic interventions, such as habitat modification, food source regulation, and public awareness initiatives, can enhance the effectiveness of pigeon population control efforts and prevent long-term stabilisation at undesirably high levels.By adopting an integrated approach that combines fertility control, habitat management, public education, and continuous monitoring, urban pigeon populations can be managed more effectively and sustainably. Learning from successful case studies in European cities provides valuable insights into how these measures can be tailored to local conditions. Future efforts should prioritise a coordinated, evidence-based strategy that addresses both biological and human-related factors, ensuring that pigeon management remains humane, effective, and adaptable over time. Future research should explore synergistic approaches, including habitat modification and stricter feeding regulations.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

Paolo Pietro Albonetti: Conceptualisation, Investigation, Methodology, Supervision, Writing – review & editing, Visualisation, Validation. Ivano Repetto: Formal analysis, Data curation, Software. Giorgio Chiaranz: Conceptualisation, Investigation, Methodology, Writing – review & editing, Visualisation, Validation. Stefano Ferretti: Conceptualisation, Investigation, Methodology, Writing – review & editing, Visualisation, Validation. Fabrizio De Massis: Conceptualisation, Investigation, Methodology, Supervision, Writing – review & editing, Visualisation, Validation.

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