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Research article

Distribution and ecology of Rock Pigeons *(Columba Livia)* in urban environments of Kazakhstan

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Abstract. This study examines the distribution and ecology of feral pigeons *(Columba livia)* in urban areas of Kazakhstan. Despite their global presence, feral pigeons have received limited attention from researchers. Understanding their distribution and ecological characteristics is crucial for managing their impact on urban ecosystems and assessing their potential as environmental indicators.

This study employs open eBird data to analyse the occurrence and distribution of feral pigeons in major cities of Kazakhstan, particularly in Almaty and Astana. Data spanning from 2007 to 2021 provide insights into their distribution in these urban areas. The study assesses the percentage of occupied regions and the extent of their range, providing information about the degree of their presence.

The findings suggest that feral pigeons are permanent residents in Kazakhstan and may exhibit migratory behavior. They have a stable and wide distribution, occupying various urban habitats. The study identifies areas with high concentrations of feral pigeons, indicating preferred locations within the cities.

The findings of this study highlight the necessity for continued monitoring and research to elucidate the distribution patterns and potential as bioindicators of environmental pollution in anthropogenic landscapes. The obtained data can serve as a basis for managing and creating sustainable and harmonious urban ecosystems that support the diversity of bird species.

Keywords: Rock Pigeon, *Columba livia*, eBird, urban ecosystem, environmental indicator.

Introduction

Rock Pigeons are highly adaptable and can be found in a wide range of habitats, including urban areas, farmland, and coastal cliffs. They are particularly common in urban environments, where they can be found nesting and roosting on buildings and other structures [1]. They are descendants of wild and domesticated rock pigeons that have colonized many cities across the globe. However, they are one of the most ignored birds by ornithologists [2]. Studies have shown that the presence of tall buildings is a significant predictor of pigeon density in urban areas [1]. However, the availability and proximity of anthropogenic food sources also play a crucial role in determining the roosting and nesting prevalence of pigeons in urban areas [3]. Pigeons tend to prefer areas with high human activity and food abundance, such as markets, restaurants, parks, and squares.

Determining the distribution of wild Rock Pigeons in Kazakhstan is challenging due to their long history of domestication. These pigeons were exported to different regions, released, and became feral. As a result, feral pigeons can now be found both within and beyond the natural range of their wild counterparts. Distinguishing between wild and feral pigeons in such cases is often difficult [4]. Additionally, traditional methods such as population monitoring through ringing have proven to be less efficient in accurately assessing their population trend in this context [5].

In Kazakhstan, there are two subspecies: *C. livia* livia and *C. livia neglecta. C. l. livia* inhabits the northern half of Kazakhstan, extending south to Mangyshlak, Mugalzhar, and Zaisan, where it intergrades with *C. l. neglecta,* while it is found in the southern half of Kazakhstan [4].

The impact of Rock Pigeons in urban environments can vary depending on the region. In some areas, they are considered a nuisance and can cause damage to buildings and other structures. In other areas, they are valued for their role in urban ecosystem services, such as providing a food source for predators and contributing to nutrient cycling. They can help to connect humans with nature and biodiversity in urban settings [6].

Rock pigeons can also compete with native bird species for resources such as food and nesting sites [7]. Furthermore, they can spread diseases to humans and other animals through their droppings and ectoparasites [8]. Rock Pigeons are known to carry various parasites and pathogens that can affect humans and other animals, such as nematodes, cestodes, avian lice, salmonella, chlamydia, and histoplasmosis [8, 9]. The invasiveness of Rock Pigeons depends on the availability of suitable habitats and food sources in urban areas, as well as the presence or absence of predators and competitors.

Rock Pigeons have shown remarkable phenotypic and genetic variation among and within urban populations, reflecting their diverse origins and selective pressures. For example, Rock Pigeons exhibit different plumage colors and patterns that may be influenced by natural or sexual selection, genetic drift, or human preference [10]. They also show different physiological and behavioral traits that may help them cope with urban stressors, such as noise, pollution, predators, and competitors [10, 11].

Rock pigeons in urban areas can serve as environmental indicators or model organisms for ecological research [12]. The Omarova et all [13] sought to establish a relationship between

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heavy metal pollution levels in various areas of Almaty city of Kazakhstan and the cardiovascular conditions of pigeons, indicating their potential as bioindicators for environmental pollution and cardiovascular diseases, highlighting the need for further research.

In Borodikhin's 1968 work, three species of Columbiformes were listed: *S. Orientalis, S. Senegalensis,* and *S. Turtur.* However, the species *Columba livia* was not mentioned [14]. t was subsequently mentioned in a 1988 work [15], and Kovshar, in his 2008 study, considered them to be among the most stable nesting species in Almaty, along with 15 other species that nested in the city throughout the 20th century and continue to nest there now [16],

The Berezovikov [17] noticed the new feeding habits of grey pigeons in Kazakhstani cities, where they have started consuming fruits such as *Malus baccata, Elaeagnus angustifolia* [18], *Cornus sanguinea, Parthenocissus quinquefolia and Robinia pseudoacacia* [19] different crops. This change in diet is likely the result of a lack of natural food sources, possibly replacing obsolete dumpsters with modern ones, which limits the bird's access to food waste [17].

This article aims to explore the ecology of Rock Pigeons in urban environments using open data sources, such as GBIF and Ebird. In other hand, open data sources may not provide information on all aspects of Rock Pigeon ecology, such as their behavior and physiology [12]. By analyzing the occurrence and distribution of Rock Pigeon data in different cities of Kazakhstan, including their average abundance, seasonal population, occupied region, and days of presence. The goal is to understand their population dynamics, and ecology in urban environments and identify any correlations between these factors.

In urban bird ecology research, leveraging open data sources like GBIF and eBird has significantly expanded the ability to study species over wide areas and periods. These platforms collect vast amounts of observations from a global community, offering a deep dive into bird distribution and behavior in cities. However, this approach comes with challenges, including variable data accuracy due to the diverse expertise of contributors and a tendency for data to concentrate in urban areas, potentially skewing species distribution insights. To address these issues, researchers integrate this data with direct field observations and use sophisticated statistical methods to ensure accuracy. Efforts to improve data collection practices among citizen scientists are also crucial for enhancing data quality. Despite its challenges, using GBIF and eBird effectively can provide valuable insights into urban bird ecology, making it a useful tool for scientists studying avian species like the Rock Pigeon in city environments.

Methodology

Study area

The study area for this research encompassed various regions of Kazakhstan, with a specific focus on the major cities of Almaty and Astana. The objective of the study was to investigate the population dynamics and characteristics of Rock Pigeons in urban environments.

Data collection

The methodology was adapted from the protocols and guidelines provided by eBird.org, a widely recognized and reputable platform for collecting bird observation data. The specific citation you mentioned, Fink et al. [20], outlines the eBird Status and Trends data version released in 2021, which served as a valuable resource for this research.

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Data analysis

Estimating Average Relative Abundance: The average relative abundance of Rock Pigeons in each city was estimated based on the number of observed individuals and the total number of checklists submitted during the study period. This metric provided insights into the overall density and population size of Rock Pigeons in specific areas.

Assessing Percentage of Seasonal Population: To determine the percentage of seasonal population, the relative abundance of Rock Pigeons within the study region was compared to the global estimated relative abundance for a particular season. This calculation involved dividing the sum of the estimated relative abundance within the study region by the sum of the estimated relative abundance across the world.

Determining Occupied Region Percentage: The occupied region percentage indicated the proportion of the selected region that fell within the range boundary of Rock Pigeons for a given season. It was determined by considering the modeled range boundary of the species and identifying the portion of the selected region that fell within this boundary.

Analyzing Days of Presence: The number of days of presence represented the duration for which Rock Pigeons were observed in the selected region. It was calculated based on spatial presence, considering that the species was present in at least 5% of the territory of the selected region, as estimated from the average relative abundance for the corresponding season.

Statistical Analyses: The collected data underwent statistical analyses to uncover meaningful patterns and relationships. Descriptive statistics, such as means and percentages, were calculated to summarize the population characteristics and distribution patterns of Rock Pigeons in the study cities. Spatial analyses, including mapping and spatial clustering techniques, may have been employed to visualize the occupied regions and assess the spatial distribution of the species.

The graphs of results were generated using the R statistical program and MS Excel [21].

Discussion

Understanding the distribution and ecological aspects of the Rock Pigeon is for effective urban wildlife management. The variation in mean relative abundance across regions indicates differences in habitat suitability and food availability. Almaty city, East Kazakhstan, and South Kazakhstan exhibit higher abundance, which can be attributed to a combination of suitable urban habitats and food sources. The higher percentage of region occupied in Almaty and Astana cities shows the adaptability of Rock Pigeons to urban landscapes. Urbanization, availability of nesting sites, and access to anthropogenic food sources influence their distribution [22].

Urbanization may have a significant impact on Rock Pigeon populations, as seen in their preference for areas with high human activity and food abundance. The presence of tall buildings and urban structures can also influence their density in urban environments [23].

Rock Pigeons have adapted remarkably well to urban environments, thriving where many species struggle. This success can largely be attributed to their ability to exploit human-provided resources and the urban landscape itself. Research has shown that pigeons find ample food from human activities and safe nesting sites in tall buildings, leading to higher breeding densities in

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cities [24]. Moreover, urban settings provide a peculiar advantage by offering protection from predators and consistent food sources, even though they come with their own set of challenges such as food scarcity during certain periods, which significantly impacts pigeon populations [25].

Results

The findings of this study reveal that the Rock Pigeon in Kazakhstan is predominantly a sedentary species, with populations that may undertake migration. The data collected demonstrates that the Rock Pigeon is present throughout the year in the studied territories, indicating a resident population (Fig 1).

The Rock Pigeon is considered a common species in Kazakhstan, with its presence observed consistently across the different regions. The analysis of the data indicates that the species occupies a significant percentage of the selected regions, with high levels of occupancy recorded in several areas. Furthermore, the Rock Pigeon exhibits a relatively stable and widespread distribution, occupying a range of habitats in urban environments (Fig 1).
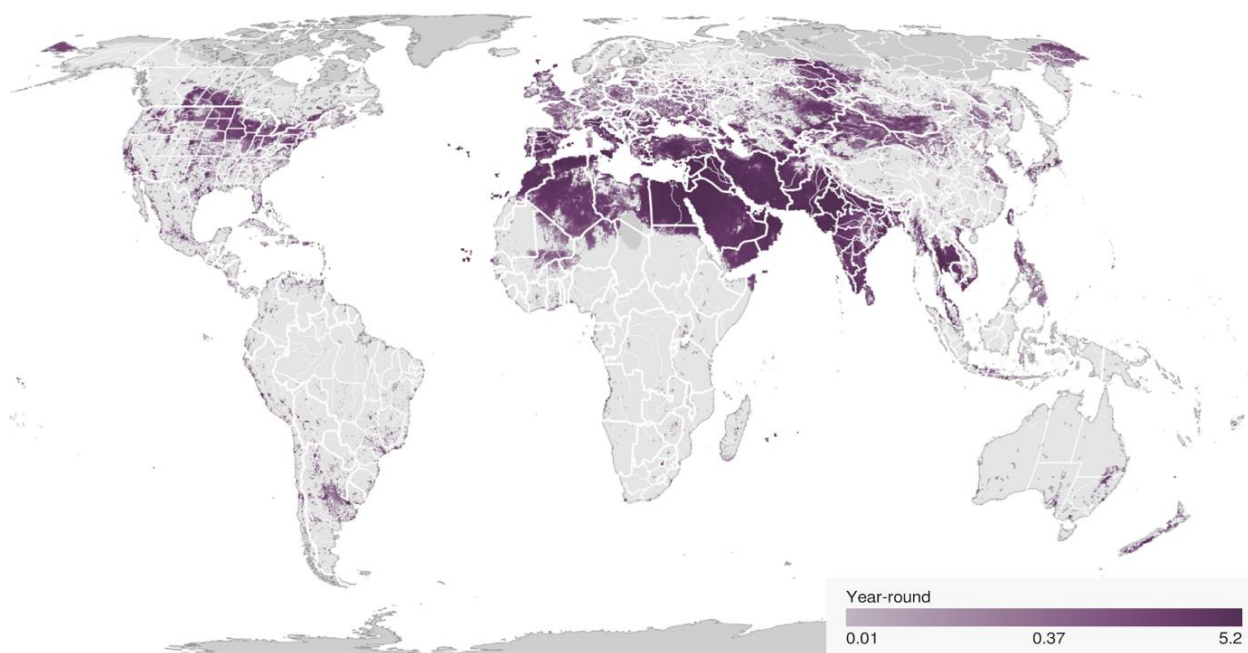

Figure 1

Abundance of Rock Pigeon Columba Livia Relative abundance is depicted for each season along a color gradient from a light color indicating lower relative abundance to a dark color indicating a higher relative abundance. Relative abundance is the estimated average count of individuals detected by an eBirder during a 1 hour, 1 kilometer traveling checklist at the optimal time of day

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for each species. eBird data from 2007-2021. Estimated for 2021. Fink, D. et al. 2022. eBird Status and Trends, Data Version: 2021: Released: 2022. Cornell Lab of Ornithology, Ithaca, New York. Powered by eBird. https://doi.org/10.2173/ebirdst.2021

The Table 1 shows the mean relative abundance, percentage of seasonal population, percentage of region occupied, and percentage of range in region for rock pigeons in various regions and cities in Kazakhstan.

Table 1

The mean relative abundance, percentage of seasonal population, percentage of region occupied, and percentage of range in region for Rock Pigeons in various regions of Kazakhstan. Source: eBird.org

Region/city	Mean relative abundance	Percentage of seasonal population	Percentage of region occupied
Astana city	4	0	91%
Almaty city	10.6	0	100%
Almaty, Jetisu	0.6	0.2%	36%
Aqmola	0.1	0	5%
Aqtobe	0.03	0	2%
Atyrau	0.02	…	0.9%
East Kazakhstan	0.7	0.4%	52%
Mangystau	0.2	0.1%	17%
North Kazakhstan	0.04	0%	2%
Pavlodar	0.1	0%	9%
Qaraghandy	0.1	0.1%	14%
Qostanay	0.01	0	0.6%
Qyzylorda	0.07	0	3%
South Kazakhstan	0.3	0.1%	13%
West Kazakhstan	0.01	…	0.3%
Zhambyl	0.3	0.1%	26%

The mean relative abundance varied across regions, with the highest values observed in Almaty city (10.6), East Kazakhstan (0.7), and South Kazakhstan (0.3). In contrast, Qostanay and West Kazakhstan exhibited the lowest mean relative abundance (0.01 each). These variations in abundance may be influenced by factors such as habitat suitability, food availability, and human activity.

The percentage of seasonal population was generally low across most regions, indicating that Rock Pigeon populations in Kazakhstan are predominantly sedentary. However, slightly higher percentages were observed in Almaty, Jetisu (0.2%), and East Kazakhstan (0.4%), suggesting

a seasonal concentration of Rock Pigeons in these areas. Further investigations are required to determine the drivers of these seasonal variations and their implications for the species' ecology.

The percentage of regions occupied varied significantly among the studied areas (Fig 2). Almaty city and Astana city exhibited high percentages of regional occupation, with 100% and 91% respectively, indicating a widespread presence of Rock Pigeons throughout these regions. Other regions, such as East Kazakhstan (52%), Almaty, Jetisu regions (36%) and Zhambyl (26%), also showed substantial occupation by the species. In contrast, Qostanay had the lowest percentage of regions occupied (0.6%). These findings indicate that habitat suitability and urbanization levels play a significant role in determining the presence and distribution of Rock Pigeons across different regions. However, it is important to acknowledge that the observed variations in occupation may also be influenced by factors such as limited birdwatching activities and underreporting of sightings. It is possible that there could be a higher occupancy of Rock Pigeons in certain areas, but due to a lack of recorded data or reporting, their presence may go unnoticed.
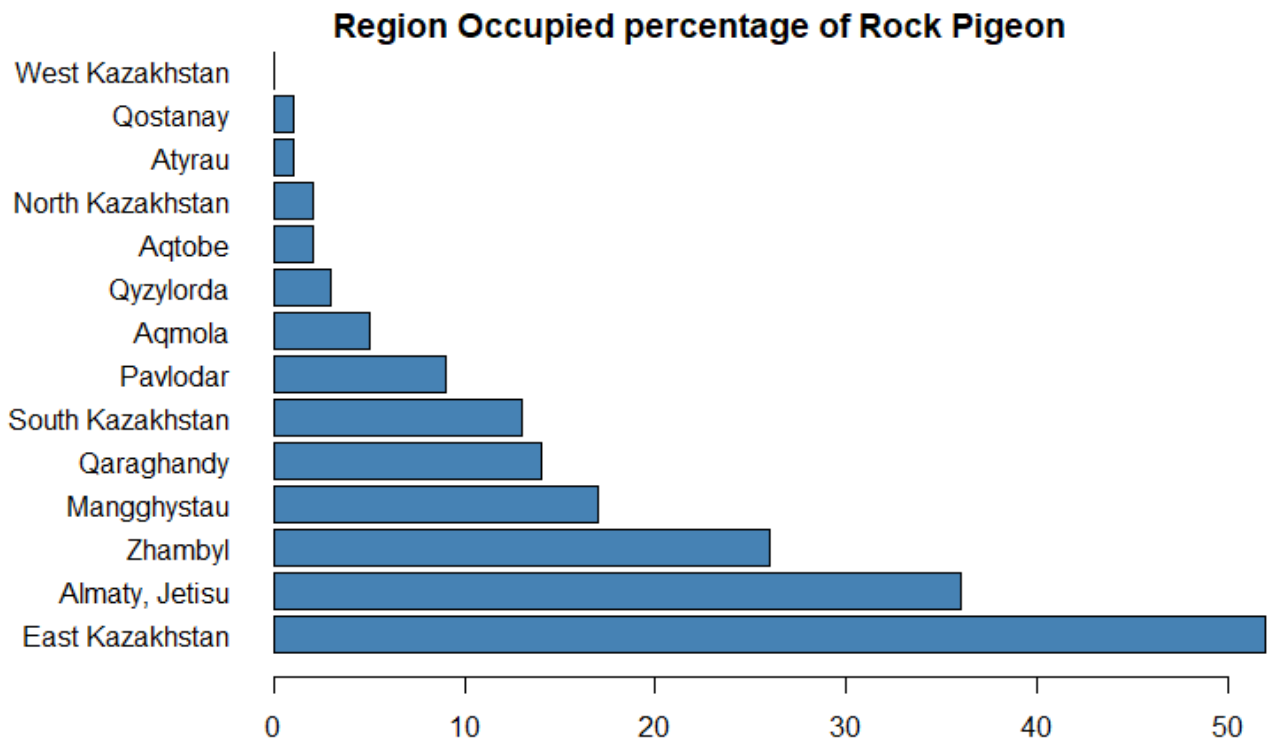

Figure 2. Region Occupied Percentage of Rock Pigeon by the regions of Kazakhstan

The percentage of range in the region was generally low across all areas, indicating that the selected regions represent only a small portion of the Rock Pigeon's total range. Almaty city had the highest percentage (0.5%), suggesting a limited extent of the species' range within the city. Other regions had negligible percentages, suggesting a limited extent of the species' range within those areas. The results emphasize the need for further research to assess the species' range and its ecological implications in Kazakhstan.

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Conclusion

In conclusion, this study provides insights into the ecology and population dynamics of Rock Pigeons *(Columba livia)* in urban environments in Kazakhstan. The findings reveal that Rock Pigeons are common and widely distributed throughout the year in the studied regions. They show a preference for urban habitats with high human activity and food availability.

The study identified variations in abundance, seasonal population, occupied region, and range across different cities and regions. Factors such as habitat suitability, food availability, and human activity influence the abundance patterns. While Rock Pigeons in Kazakhstan are predominantly sedentary, slight seasonal concentrations were observed in some areas.

Habitat suitability and urbanization levels play a significant role in determining the presence and distribution of Rock Pigeons. However, limitations in birdwatching activities and underreporting of sightings may underestimate their occupancy in certain areas. The Rock Pigeons serve roles in the urban ecosystem, in other hand their abundance raises concerns about disease transmission and ecosystem imbalance.

The study highlights the importance of continued monitoring and research to understand Rock Pigeon ecology, including their interactions with native species, human activities, and environmental factors.

Acknowledgments

Authors' contribution

Bekzhan Berdikulov: Principal author of the manuscript. He is participated in data collection and analysis.

Andrey Gavrilov: Supervisor of the study. Andrey provided scientific advice, helped develop the methodology, and participated in data collection.

Samat Bekbenbetov: Actively participated in field data collection, ensuring the high quality of the collected materials.

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Көк кептердің *(Columba Livia)* Қазақстанның қалалық жерлерінде таралуы мен экологиясы

Аңдатпа. Бұл мақалада Қазақстанның қалалық аудандарында көк кептердің *(Columba livia)* таралуы мен экологиясы зерттеледі. Көк кептерлердің әлемде кең таралуына қарамастан, зерттеушілер бұл түрді назарға алмай жатады. Олардың таралуы мен экологиясын түсіну – қала экожүйесіне әсерін білуде және экологиялық индикатор ретіндегі әлеуетін бағалауда маңызы зор.

Бұл зерттеуде eBird ашық деректерін пайдалана отырып, Қазақстанның барлық өңірі мен Алматы, Астана сияқты ірі қалаларда көп кептердің таралуы туралы айтылады. 2007 жылдан 2021 жылға дейінгі деректер түрдің қалалық жерлерде таралуы туралы мәлімет береді. Зерттеуде олардың аталған маңда кездесу дәрежесі, маусымдық өзгерістері мен аймақтарды қамту пайызы туралы нәтижелер бар.

Нәтиже бойынша, көк кептердің Қазақстанда тұрақты түр екенін және аздап миграция жасайтыны айтылады. Олар көптеген урбанистикалық аймақтарда тұрақты әрі кең таралған. Сондай-ақ, зерттеуде көк кептердің көп шоғырланған аймақтары анықталады.

Зерттеу қорытындысы бойынша көк кептерді антропогендік ландшафттардағы қоршаған ортаның ластануының биоиндикаторлары ретінде пайдалану үшін үздіксіз мониторинг пен зерттеу жүргізу қажеттігін көрсетті. Нәтижелер орнитофауна алуандығын қолдайтын тұрақты және үйлесімді қалалық экожүйелерді басқаруда пайдалы бола алады.

Түйін сөздер: көк көгершін, *Columba livia,* ebird, қалалық экожүйе, экологиялық көрсеткіш.

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Распространение и экология сизых голубей *(Columba Livia)* в урбанистических районах

Аннотация. В данном исследовании изучается распространение и экология сизых голубей *(Columba livia)* в городских районах Казахстана. Несмотря на своё глобальное присутствие, сизые голуби привлекли ограниченное внимание исследователей. Понимание их распространения и экологических характеристик имеет решающее значение для управления их воздействием на городские экосистемы и оценки их потенциала в качестве экологических индикаторов.

Используя открытые данные eBird, в этом исследовании анализируется встречаемость и распространение сизых голубей в крупных городах Казахстана, в частности, в Алматы и Астане. Данные с 2007 по 2021 год предоставляют представление об их распределении в этих городских районах. В исследовании оценивается процент занимаемых регионов и охват ареалов, предоставляя информацию о степени их присутствия.

Результаты показывают, что сизые голуби являются постоянными видами в Казахстане и, возможно, проявляют миграционное поведение. Они имеют стабильное и широкое распространение, занимая различные урбанистические местообитания. Исследование определяет районы с высокой концентрацией сизых голубей, указывая предпочтительные места в городах.

В этом исследовании подчёркивается необходимость проведения постоянного мониторинга и исследований для понимания моделей их распространения и потенциала в качестве биоиндикаторов загрязнения окружающей среды в антропогенных ландшафтах. Полученные данные могут стать основой управления и создания устойчивых и гармоничных городских экосистем, поддерживающих разнообразие орнитофауны.

Ключевые слова: сизый голубь, *Columba livia*, ebird, городская экосистема, экологический индикатор.

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