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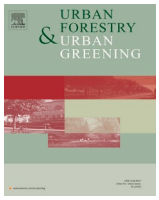

Original article

Engaging students in research to obtain ethnobotanical insights: Exploring ecosystem services in an urban park in Rimini (Emilia-Romagna, Italy)

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ABSTRACT

Urban foraging has recently become popular as a way for people to reconnect with nature and to apply the traditional ethnobotanical knowledge in an urban context. In this study a two-year ethnobotanical survey was conducted in an urban park in Rimini, Italy, through a citizen science approach involving high school students as interviewers. The aim of the study was to assess the willingness to forage in an urban context and to document the local knowledge of wild plants. A total of 176 informants were interviewed, providing data on plant uses across eight distinct categories. The majority of informants (53.4%) are willing to forage in urban parks, but a significant proportion (30.7%) was unfavourable to this practice, citing concerns about plant pollution and potential legal issues, among other reasons. Knowledge of gathering was mainly acquired from family members and friends, although one-fourth of the respondents learned to forage through self-learning. Within the sample, there were differences in the willingness to forage based on gender, age and learning groups, but these were not statistically significant. A total of 90 plant species belonging to 45 families was reported in the survey, and the most cited plants were in the food category. The engagement of high school students as co-researchers turned effective for collecting ethnobotanical data, even though some limitations emerged. Addressing the critical issues raised by foragers and investigating the effects of these measures opens up future prospects for continuing research.

1. Introduction

Urban green spaces are increasingly recognized as important places for fostering connections between humans and nature in cities. Over the past few decades, substantial research has demonstrated the health and well-being benefits of these connections. These benefits include physical health (Kaczynski et al., 2008; Tauber, 2012), psychological health (Kardan et al., 2015; Wang et al., 2025), and social health (van den Berg et al. 2010), and they have been observed across different age, gender, and socioeconomic groups.

Urban public green spaces also play a vital role in providing refuge for plants, animals and microorganisms (Baruch et al., 2021; Zhao et al., 2022), thereby contributing to the maintenance of biodiversity in densely populated and rapidly expanding urban areas (Nielsen et al., 2014; Kowarik, 2011; Aronson et al., 2017; Fischer and Kowarik, 2020). Biodiversity in urban green spaces has been shown to enhance human well-being, with higher psychological benefits reported in areas characterised by greater species richness. In particular, plant diversity appears to play a key role in shaping visitors' experiences of urban nature, often more strongly than other taxonomic groups such as birds or butterflies (Fuller et al., 2007).

Beyond these benefits, urban biodiversity underpins a range of cultural ecosystem services, including the possibility for urban residents to gather non-timber and timber forest products such as mushrooms, berries, fruits, leaves and flowers. These resources are used for food, medicine, decoration and other purposes, and their collection often contributes to the maintenance and transmission of ethnobotanical knowledge and cultural heritage (Landor-Yamagata et al., 2018; Grivins, 2024). Such foraging practices are widespread in urban and peri-urban environments and occur in diverse settings, including public parks, suburban streets and private gardens (McLain et al., 2014; Shackleton et al., 2017; Brandner and Schunko, 2022). While urban foraging has been extensively studied in the Global South, it has only recently attracted growing attention in the Global North, where existing research remains largely concentrated in Northern and Western Europe and North America (Shortly and Kepe, 2021; Sivarajah et al., 2024).

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As in other European countries, traditional knowledge of plant uses in Italy is disappearing. However, a renewed interest in wild edible plants has emerged in recent years, which can be interpreted as part of a broader re-engagement with nature and rural identities in urban settings, a phenomenon associated with neo-rurality and the revival of traditional knowledge (Łuczaj et al., 2012; Sansanelli and Tassoni, 2014; Sansanelli et al., 2017; Paura et al., 2021). While this trend is well documented in rural areas, little is known about whether and how it manifests in urban environments, and whether urban foraging can be considered somehow an expression of this emerging neo-rurality.

Another under-explored aspect is the methodological approaches used to collect ethnobotanical information. Traditional ethnobotanical surveys, which are based on snowball sampling and researcher-led interviews, face more limitations in urban contexts, which are characterised by more heterogeneous populations than peri-urban and rural areas. In this regard, a citizen science approach, which has been widely adopted in urban ecology but is still under-explored in ethnobotanical studies (Grasser et al., 2016; Ploetz and Orr, 2004), could help address these limitations by enabling increasing sampling breadth (Goffredo et al., 2010) and strengthening the science–society relationships (Bird et al., 2014; Wals et al., 2014).

To fill these gaps, we conducted, for the first time in Italy, an ethnobotanical survey in an urban context using a citizen science approach, while simultaneously exploring the role of a public park in supporting urban foraging practices. High school students were engaged as co-researchers to collect ethnobotanical information in a medium-sized urban park in Rimini (Italy). The study pursued three main objectives: (i) to investigate citizens' willingness towards foraging in an urban park and the plant species most commonly used by them; (ii) to identify current and potential ethnobotany-related ecosystem services provided by urban green spaces, as well as the barriers limiting access to these services; and (iii) to assess the suitability of citizen science approaches for collecting ethnobotanical data in heterogeneous urban contexts.

2. Methods

2.1. Study area

The study was conducted for two years, from October 2021 to May 2023 in Rimini, a medium-sized Italian city with a population of around 150,000, located on the Adriatic coast in northern Italy. The study took place in Ausa Park, a public green space that crosses the town and splits it into two parts, following the old course of the Ausa River. Today, this park is considered an important area as it is the city's main "green lung" and a social meeting point. Extending for 14 ha from the city centre to the coast, it runs alongside the historic city walls and is considered a medium-sized urban park (Brandner et al., 2025). Although it is perceived by citizens as a single park, it is actually composed of six public green spaces: Giovanni Paolo II (Cava) Park; Fabbri Park; Olga Bondi Park; Alcide Cervi Park; Maria Callas Park; and Madre Elisabetta Renzi Park (Fig. 1).

2.2. Sample and data collection

To conduct the ethnobotanical surveys, a citizen science approach was applied. A total of 38 students, all aged 16–18, from two high schools located in Rimini were engaged as interviewers. In the 2021/22 academic year, 14 students were recruited: two from the fourth year and five from the fifth year of the scientific high school "*Liceo Scientifico Statale Albert Einstein*" (Municipality of Rimini), and seven from the fourth year of the scientific and artistic high school "*Liceo Statale Scientifico e Artistico Alessandro Volta – Federico Fellini*" (Municipality of Riccione). In the 2022/23 academic year, 24 students were recruited from the third year of the scientific high school "*Liceo Scientifico Statale Albert Einstein*", in Rimini. The students were participating in the Italian Ministry of Education's programme, "*Percorsi per le Competenze Trasversali e l'Orientamento (PCTO)*". This programme consists of compulsory training courses in the final three years of Italian secondary school,

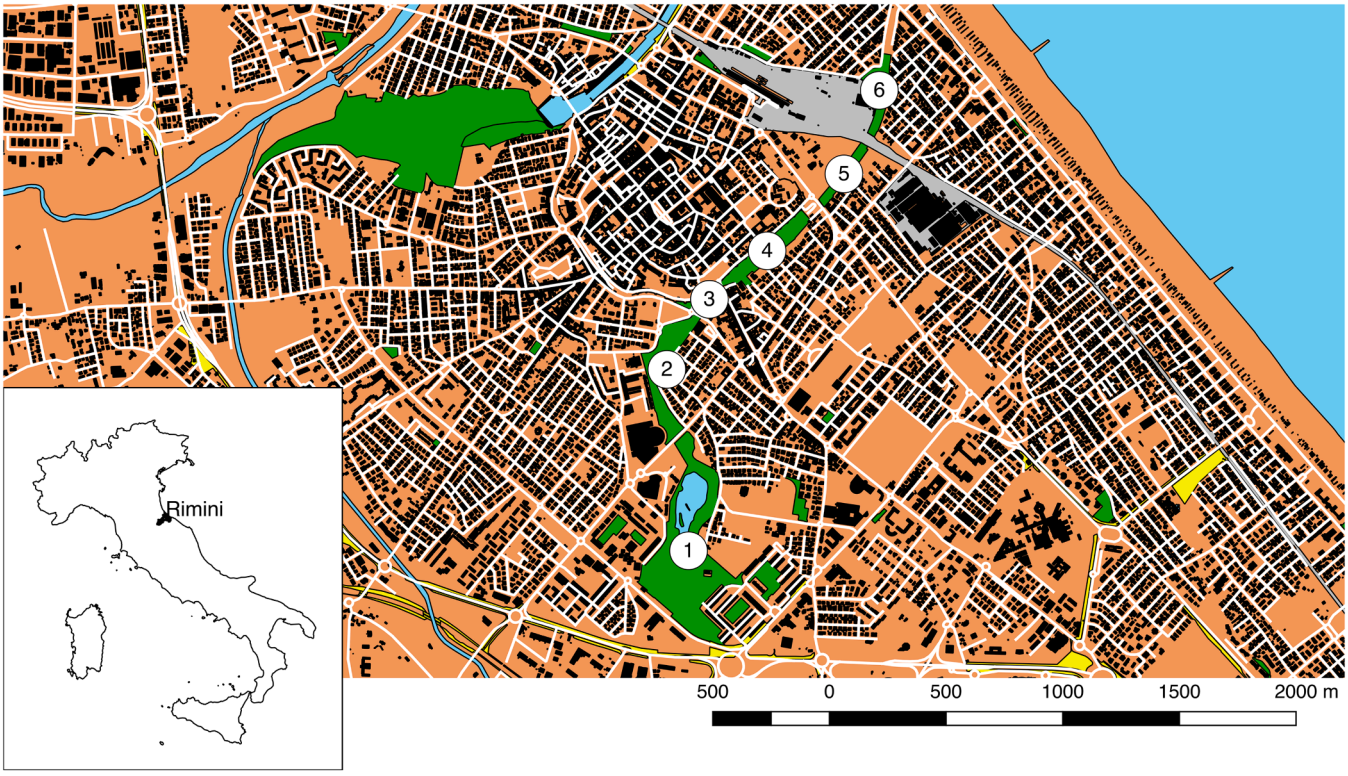

Fig. 1. Location of Ausa area in Rimini, Emilia-Romagna region, Italy. Different numbers represent the various urban sections of the park. From inland to sea: 1) Giovanni Paolo II (Cava) park, 2) Fabbri park, 3) Olga Bondi park, 4) Alcide Cervi park, 5) Maria Callas park and 6) Madre Elisabetta Renzi park.

aimed at developing cross skills and preparing students for the workforce and university. The main purpose is to enhance students' CVs with practical experience, such as internships, and help them discover their aptitudes while improving their problem-solving, communication and teamwork skills.

The students who took part in the programme attended a training course in ethnobotany, during which they learned how to conduct semi-structured interviews. Before starting the survey, they practised making interviews with each other and their relatives to familiarise themselves with the procedure and the structure of the form, and a simulation with the authors was carried out to check for the correct application of the procedure. Once the students were ready to conduct the interviews, one of the authors (SF) supervised them during the first period of the survey in both years. As a member of the Ecomuseo of Rimini (Italy), an association for social promotion of local heritage and territory, SF continued to support the students throughout the PCTO programme, connecting them with the University team.

The semi-structured interview was based on the work of Land-or-Yamagata et al. (2018). The drafted interview guide therefore included open-ended questions divided into four sections: (A) background; (B) gathered plants; (C) personal information (gender, intended to encompass all identities, not just male or female); and (D) a unique code based on personal information (see Table 1).

Section A was fundamental in engaging with the informants and initially collecting information on the perception of foraging in an urban park through open questions and subsequently gathering information on plant uses. Section B was used to report all the mentioned plants with their related uses, and section C was used to gather foragers' background information and build the univocal code reported in section D. Section C includes both mandatory fields (initials, age, gender, and Italian provincial code of birthplace) and non-mandatory fields (educational background and professional position). This distinction was made to avoid putting respondents in an uncomfortable position when answering questions related to their socioeconomic status, and to avoid interviewers from having to insist on obtaining such information. Eight different use categories for mentioned plants were included: food, ornamental, medicinal, cosmetic, recreational, agro-pastoral, domestic, repellent.

The respondents mostly referred to foraged species by a common name (in Italian or in local dialect), which was the starting point for identification. Vernacular plant names reported by informants were subsequently standardized and matched to scientific taxa by the research team using regional and local floristic manuals (Beggio and Lazzari, 2019), and an official regional checklist (Bartolucci et al., 2018). This procedure allowed to verify the correspondence between local names and accepted botanical species.

Table 1
Structure of the interview guide used to gather information from Rimini foragers. Non mandatory fields are marked with an asterisk.

(A)	Background	(C)	Personal information
	How did you learn to gather wild plants?		Initials (first and last name) – (AA) Age – (00)
	Do you gather, or would you be willing to gather, plants in urban parks?		Gender – (F/M/X)
	Do you gather, or would you be willing to gather, plants in urban parks? If not, why not?		Italian provincial code of birthplace – (BB) *Educational background *Professional position
	Gathered plants		**Univocal code**
(B)	When you forage, what plants do you gather? For which purposes? Plant name Uses Notes	(D)	AA-00-F/M/X-BB

All information was collected anonymously by the students, and the univocal code allowed to track the information provided by each respondent. The students recruited informants both randomly, by directly approaching the park visitors, and through a snowball sampling method, exploiting the network of contacts of visitors who were also regular park users. The interviews were conducted in Italian, and only people who foraged for wild plants were considered as informants.

2.3. Data analysis

The information collected from the interviews was transcribed and analyzed by qualitative content analysis using the content-structuring type (Mayring, 2014). The responses were coded manually, according to a set of predefined categories corresponding to the structure of the semi-structured interview, covering topics such as the foragers' learning channels, their willingness to forage in urban parks, the plants they gathered and how they used them. Subsequentially, subcodes were determined inductively. These coded data were then clustered to summarize the interview content and transformed into frequencies. All the data were entered into a Microsoft Excel (ver. 16.16.27) spreadsheet, filling in the following fields: informant code, survey year, informant age, informant gender, learning channel, willingness to forage in urban parks, common plant name, scientific plant name, plant family, and plant use. Scientific plant names were updated according to the World Flora Online (WFO) Plant List (World Flora Online, 2025).

Chi-squared tests were conducted in Microsoft Excel to assess whether the gender distribution of informants differed across the two years. In the R environment (ver. 4.4.3, R Core Team, 2025), a Wilcoxon rank-sum test was applied to analyse differences in the age distribution of informants between the two study years.

Binary logistic regression analyses were performed using the nnet package (Venables and Ripley, 2002) to investigate the potential factors influencing (i) the willingness of foragers to forage in urban parks and (ii) the presence of missing information in the recorded data. The interaction effects among the explanatory variables were assessed by comparing models with and without interaction terms using chi-square tests. The potential confounding effects were evaluated by examining the changes in odds ratios (ORs) after including covariates in the models. Variations in ORs of less than 10% were interpreted as indicating the absence of confounding factors. For the first analysis, the response variable was foragers' willingness to forage in urban parks (favorable or unfavorable). The explanatory variables included gender (male or female), age group ($\leq$ 30, 31–60 or $\geq$ 61 years), and mode of learning (oral transmission or self-learning). For the second analysis, the presence or absence of mandatory missing information in the recorded data was used as the response variable. Gender (male or female) and age group ($\leq$ 30, 31–60 or $\geq$ 61 years) were included as explanatory variables. To avoid empty cells and ensure model stability, informants in both datasets were grouped into three age groups. Similarly, in the first dataset, mode of learning was classified into only two categories, oral transmission and self-learning, to ensure the stability of the model. In this context, oral transmission refers to knowledge acquired through family members and close community networks. Social media and other digital learning channels were included in the self-learning category due to their low frequency. Due to the small sample size, the robustness of the results from both analyses was evaluated by fitting additional binary logistic regression models that incorporated bootstrap resampling (1000 iterations) and ridge regularization. For all statistical analyses, statistical significance was assessed using a p-value < 0.05.

3. Results

During the two-year survey, 35 out of the 38 participating students interviewed a total of 176 informants (68 in the first year and 108 in the second year). These informants were distributed between 111 females and 65 males and were aged between 5 (the youngest girl with her

grandmother) and 91 years. All informants stated that they gather wild plants. Mandatory information, such as the willingness of respondents to forage, was not recorded in 16% of the interviews. Additionally, non-mandatory personal data, such as educational background and professional position, were reported in only 60% and 40% of interviews, respectively (data not shown). These were therefore excluded from the analysis.

In both years, the female group was larger than the male group (61.8% and 63.9% in the first and second years, respectively), with an average age of 51.5 and 53.4, respectively. A similar average age was found within the male group. The detailed distributions of the number of informants, their gender and average age for each year of the survey are reported in Table 2. The chi-square analysis showed no significant differences in the frequency of male and female foragers between the two years of the study (χ^2 (1, $N = 176$) = 0.78, p-value = 0.378). Similarly, Wilcoxon rank-sum tests revealed no significant differences in the age distribution of male (p-value = 0.065), female (p-value = 0.697) or all (p-value = 0.158) respondents across the two years of the study.

When considering both years, the majority of interviewees (65.9%) reported that they had acquired their foraging knowledge through oral transmission from family members and close community networks. This was followed by self-learning (25.6%), while a smaller proportion (8.5%) did not respond to this question. Among self-learners (n = 45), books were the predominant learning source, while only a small number reported learning through online content, specifically videos on social media (n = 2) and internet blogs (n = 3). During the survey, informants were also asked about the suitability of urban parks for foraging. Overall, 53.4% considered these areas to be suitable for foraging, 30.7% disagreed, and 15.9% did not respond. Reported reasons for avoiding urban parks included: *"Urban parks are polluted due to traffic"*, *"Urban parks have too much dog faeces"*, "*Foraging is meant to take place in nature*", *"Being in nature is fundamental to making the foraging experience fulfilling and satisfying*", *"I don't want to break the rules"*, *"Foraging in urban parks could damage public property"*, "*I am worried about being accused of theft"*, and *"It is embarrassing to forage in crowded places"*.

The results of the binary logistic regression analyses investigating foragers' willingness to forage in urban parks are displayed in Fig. 2A and summarized in Supplementary Table 1A. The outcome was coded as "unfavorable" (reference: favorable), meaning that odds ratios (ORs) greater than 1 indicate a higher probability of an unfavorable response, i.e., lower willingness to forage. None of the examined variables showed statistically significant associations with willingness to forage. Although no statistically significant effects were detected ($p > 0.05$), descriptive tendencies in the direction of lower willingness among men aged 61 years or over and among participants who learned independently were observed, as well as a tendency towards greater willingness among participants aged 30 years or under.

Adjusting for potential confounders had a minimal impact on the effect estimates, suggesting that no relevant confounding factors were present. Model comparisons using likelihood ratio tests showed that the inclusion of gender (χ^2 (1) = 0.412, p-value = 0.521), age group (χ^2 (2) = 1.378, p-value = 0.502), and learning method (χ^2 (1) = 2.234, p-value = 0.135) did not significantly improve the model's fit compared to the null model. No significant interactions were observed, indicating that the association between gender and willingness to forage did not vary across age (p-value = 0.339) and learning mode (p-value = 0.263) groups. Bootstrap resampling and ridge regularization confirmed the lack of statistically significant association, while maintaining and reinforcing the direction of the observed tendencies (Supplementary Table 1A).

Table 2
Total number of informants and relative distribution of gender and age during the two years of the survey.

Year	2021/22	2022/23
N. of informants	68	108
	Gender (informants %)	
Female	61.8	63.9
Male	38.2	36.1
Total	100	100
	Age average ± SD	
Female	51.5 ± 18.4	53.4 ± 19.8
Male	50.4 ± 19.9	59.7 ± 20.3
Total	51.1 ± 18.9	55.7 ± 20.1

The results of the binary logistic regression analyses examining the association between gender, age group, and questionnaire completeness, are displayed in Fig. 2B and reported in Supplementary Table 1B. As the outcome was coded as "negative" (reference: positive), ORs greater than 1 indicate a higher probability of incomplete responses. None of the predictors were statistically significant. Although no statistically significant effects were detected ($p > 0.05$), ORs were descriptively above 1 for the male group and for participants in the ≤ 30 and ≥ 61 age groups, indicating non-significant tendencies towards incomplete responses. Minimal changes in effect estimates after adjustment indicated the absence of relevant confounding factors. Model comparisons using likelihood ratio tests showed that including gender (χ^2 (1) = 152.97, p-value = 0.262) and age group (χ^2 (2) = 151.00, p-value = 0.373) did not significantly improve the model's fit compared to the null model. No significant interactions were observed, indicating that the association between gender and questionnaire completeness did not vary across age groups (p-value = 0.550). Bootstrap resampling and ridge regularization confirmed the lack of statistically significant associations, while preserving and reinforcing the direction of the observed tendencies (Supplementary Table 1B).

The survey identified a total of 90 plant species belonging to 45 families, with 342 citations, which were reported to be used across eight distinct fields (Supplementary Table S2). Of these, 79 were wild plants (including both native and naturalised species) and 11 were cultivated. Detailed ethnobotanical descriptions of the plant part used and mode of preparations were recorded for 65 out of 90 botanical entities (Supplementary Table S2). Lamiaceae was the most frequently cited family (105 citations), followed by Asteraceae (60 citations), Papaveraceae (18 citations) and Rosaceae and Urticaceae (17 citations). The most frequently cited wild plants were *Salvia rosmarinus* Spenn. (31 citations), *Salvia officinalis* L. and *Taraxacum* spp., followed by *Urtica dioica* L., *Papaver rhoeas* L. and *Leucanthemum vulgare* Lam.

Among the plant use categories, food was the most frequently cited, followed by ornamental and medicinal uses (Table 3).

In the food category, the most frequently cited wild plants were *Salvia rosmarinus* Spenn., *Salvia officinalis* L., *Papaver rhoeas* L., *Urtica dioica* L., *Thymus vulgaris* L., *Mentha* spp., *Silene vulgaris* (Moench) Garcke, *Eruca vesicaria* (L.) Cav., *Cichorium intybus* L., *Borago officinalis* L., *Taraxacum* spp. and *Sonchus oleraceus* L. All of the plants mentioned in this category were recognized as edible. Of these, *S. rosmarinus*, *S. officinalis*, *T. vulgaris* and *Mentha* spp. were used to flavour dishes, while *P. rhoeas*, *Beta vulgaris*, *S. vulgaris*, *E. vesicaria*, *U. dioica*, *C. intybus*, *B. officinalis*, *Taraxacum* spp. and *S. oleraceus* were commonly eaten in salads. *U. dioica* was used to fill fresh pasta, while *S. oleraceus*, together with *P. rhoeas* and *C. intybus*, was used mainly to fill "piadine" and "cassoni", traditional flatbread dishes from the Romagna region, where Rimini is located. Among species of ornamental interest, the most cited wild plants were *Leucanthemum vulgare* Lam. and *Taraxacum* spp. (Supplementary Table S2). In the medicinal category, the most frequently cited wild plants were *Lavandula angustifolia* Mill., *Matricaria chamomilla* L., *Malva sylvestris* L. and *Equisetum* spp. More specifically, *L. angustifolia* and *M. chamomilla* were cited for their sedative properties, *Equisetum* spp. was cited for its diuretic properties, and *M. sylvestris* for its emollient properties. An overview of the functional relevance of the 22 most cited species for foraging activities in Rimini, highlighting the most represented botanical families and the dominant categories of use, is reported in Fig. 3.

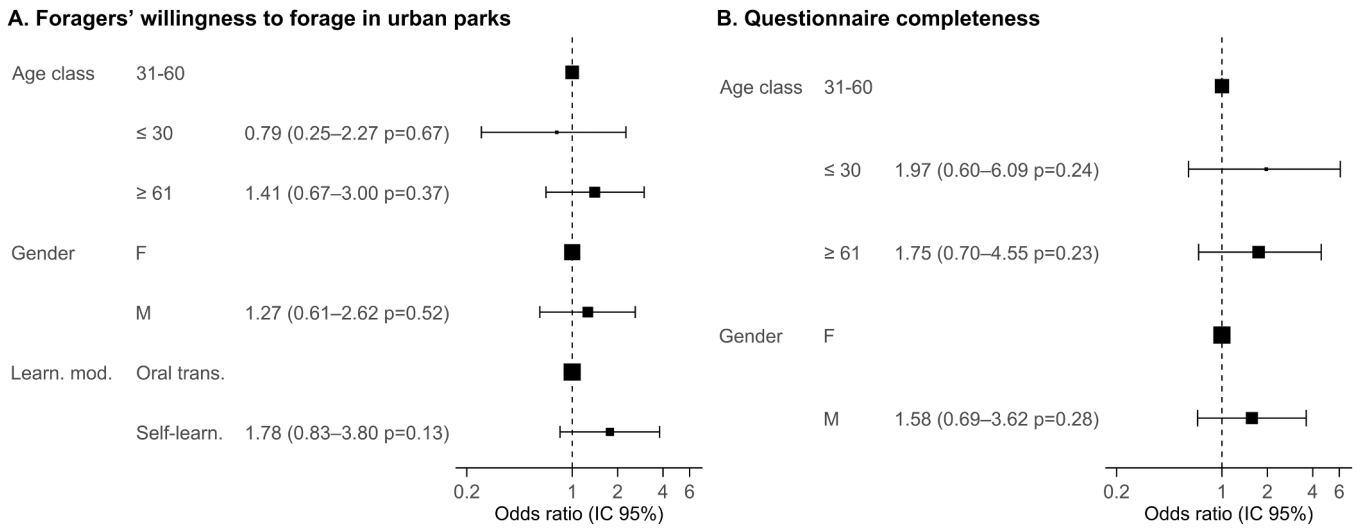

Fig. 2. Forest plot of the binary logistic regression results showing estimated odds ratios and their 95% confidence intervals (logarithmic scale) for the analyzed predictors. Odds ratios are reported together with their corresponding confidence intervals and *p*-values in parentheses. The point size is proportional to the group sample size. Panel A shows the associations between explanatory variables (age class, gender, mode of learning) and the response variable (foragers' willingness to forage in urban parks). Learn. mod: mode of learning, oral trans: oral transmission, self-learn: self-learning Panel B shows the associations between explanatory variables (age class and gender) and the response variable (questionnaire completeness).

Table 3
Distribution of citations and plant species within the eight use categories emerged from the ethnobotanical survey.

Use category	# of citations	% of citations	# of species	% of species
Food	243	71.05	58	52.0
Ornamental	61	17.83	28	25.2
Medicinal	22	6.44	13	11.7
Domestic	7	2.04	2	1.8
Agro-pastoral	3	0.88	3	2.7
Cosmetic	2	0.58	3	2.7
Recreational	2	0.58	2	1.8
Repellent	2	0.58	2	1.8

4. Discussion

In this study we applied, for the first time, a citizen science approach to carry out an ethnobotanical survey in a medium-sized (14 ha) urban green space in Rimini, Italy, to understand the attitude of citizens toward the plant foraging practice and to get information about the traditional knowledge of plants related to foraging in an urban context. The study was only focused on plants due to the expertise and background of the authors, although other non-timber forest products, such as mushrooms and insects, could also have been of interest to the study. Indeed, mushroom picking was also mentioned in 15 interviews, but this information was not taken into consideration, since it was too vague.

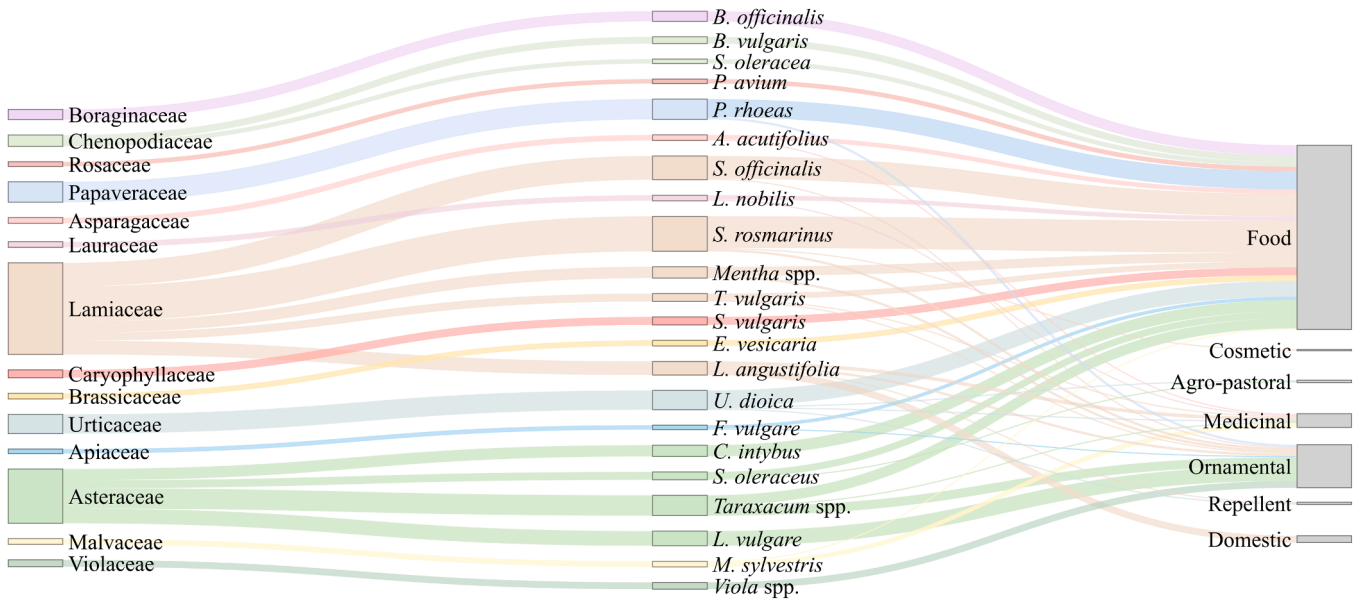

Fig. 3. Sankey diagram illustrating the connections among botanical families (left), species (center), and their respective uses (right). Only the most frequently cited wild species are included.

4.1. Forager population

The results obtained here demonstrate a higher prevalence of women than men in foraging activities in Rimini. This is not surprising, as gender has previously been shown to influence gathering activities, with several studies conducted worldwide demonstrating that women are more likely to engage in foraging, particularly the collection of wild plants (Palliwoda et al., 2017; Howard, 2003; Mollee et al., 2017; Russo and McCarthy, 2024; Somesh et al., 2021). However, in one study conducted in Lagos, Nigeria, the majority of urban gatherers were male. This was attributed to women feeling unsafe when collecting biological resources in urban foraging spaces in a city with a very high crime rate (Adeyemi and Shackleton, 2024).

However, the high proportion of women in our study may also be due to a methodological limitation, as the interviews were conducted by high school students who may have found it easier to approach women than men. Furthermore, traditional Western gender roles and the fear of aggression (Baugher and Gazmararian, 2015) could have made women more likely to visit urban parks during the daylight hours, when the interviews were conducted. Although the students were adequately trained to conduct interviews, we cannot rule out the possibility that using citizen science with such young students may have limited the representativeness of the recruited sample.

4.2. Foraging in Ausa park

Although no significant differences were found in willingness to forage among gender, age, or learning groups, we observed descriptive tendencies suggesting that older and younger age groups may differ in their attitudes towards foraging. These patterns should be interpreted with caution and considered exploratory, as they were not statistically supported in this sample. Similarly, self-learners appeared less inclined towards foraging in urban environments than foragers who benefit from long-standing traditional knowledge; however, this difference was not statistically significant and should not be interpreted as evidence of a causal relationship. The following interpretations are therefore speculative and intended to provide possible explanations for future hypothesis-driven research. One possible interpretation is that self-learners may acquire foraging skills later in life as part of a broader pursuit of healthier or more nature-oriented lifestyles, and may therefore prefer to engage in foraging activities in environments perceived as more "natural," potentially avoiding urban spaces associated with pollution, disturbance, or ambiguous land-use regulations. Previous research has already documented divergent attitudes and practices among different types of foragers. Grivins (2024), for example, distinguishes between lifestyle foragers, who operate with newly acquired knowledge, and rooted foragers, who learnt to forage in childhood and rely on traditional knowledge. This suggests that differences in learning trajectories and knowledge transmission play a key role in shaping perceptions of legitimacy, responsibility and the appropriate contexts for foraging activities.

Despite the overall favourable attitude toward foraging in urban parks observed among foragers, a considerable proportion of respondents reported being unfavourable to this practice. Their concerns can be grouped into three main categories: 1) the risk of plant contamination by pollutants and/or animal excreta; 2) the perception that the experience is less rewarding in a public park than in wild nature environments; and 3) fear of violating the public park's legal regulations.

Several studies (Landor-Yamagata et al., 2018; Russo and McCarthy, 2024; Fischer and Kowarik, 2020) reported concerns about the contamination of mushrooms, wild plants and food crops as major hindrances to urban food collection. In a recent survey, Brandner et al. (2025) examined the features of various public green spaces in Vienna which had been identified as suitable for wild food foraging, and they discovered that contamination was the primary factor influencing foragers' location selection.

Research conducted in urban allotment gardens in London, where edible crops are cultivated, reported lead concentrations in roots and leafy vegetables exceeding recommended safety thresholds (Leake et al., 2009). However, these concentrations were not detected in produce that had been appropriately washed prior to consumption. A recent review of global urban foraging by Sivarajah et al. (2024) found that many studies reported higher concentrations of heavy metals and rare earth elements in edible plants and fungi collected in urban areas compared with those from rural or peri-urban environments. These findings highlight the legitimacy of concerns about contamination.

Regarding foragers' perceptions of environmental wilderness, our findings are consistent with existing literature. In a study on preferred foraging locations across different urban green spaces in Vienna, Brandner et al. (2025) found that urban foragers tend to favour publicly accessible areas that are less intensively managed, rather than smaller and more intensively maintained spaces. This preference is likely associated with the higher biodiversity of wild food plants typically found in the former. Furthermore, in a recent study on foraging practices and perceptions of traditional knowledge in peri-urban areas near Padua (Italy), Souviney et al. (2024) reported that one quarter of interviewees had completely abandoned foraging due to the loss of access to land.

The fear of breaking the rules while foraging in urban and peri-urban green spaces is a common concern among foragers. It is a key factor that restricts urban foraging, as several studies have reported (Brandner and Schunko, 2022; Landor-Yamagata et al., 2018; McLain et al., 2014; Schunko and Brandner, 2022; Synk et al., 2017). To address this issue, specific areas within urban parks should be designated where foraging is permitted and plant parts can be collected safely, taking into account the spatial heterogeneity of contaminant accumulation (Yin et al., 2011; von Hoffen, Säumel, 2014). However, in a study conducted in Seattle (USA), Charnley et al. (2018) examined the cognitive processes underlying foragers' access to natural resources across three urban environments and concluded that feelings of guilt or fear associated with gathering may play an important role in ensuring the sustainable harvesting of urban non-timber forest products.

Despite these concerns, the informants in our study were primarily interested in foraging for herbaceous species, particularly those traditionally used in local Rimini cuisine. This finding further supports the close relationship between foraging practices and the cultural and gastronomic identity of local populations (Turner et al., 2011; Souviney et al., 2024) and indicates that the Ausa Park could serve as a place where urban residents can rediscover rural activities and reconnect with plants and their use.

4.3. Most used plants

All of the reported uses across the eight categories are well-known and have been frequently documented in Italian ethnobotanical surveys (Chiocchio et al., 2024; Paura et al., 2021; Sansanelli and Tassoni, 2014). Analyzing the ornamental category, the mentioned plants were quite heterogenous, as they are collected solely for decorative and ornamental purposes. Thus, the selection of ornamental plants was based only on personal preferences of the respondents, rather than on specific plant properties and/or edibility, as in the food and medicinal categories. Analyzing plants in these categories (Fig. 4), it appears that respondents are generally able to recognize the edibility of the species mentioned in the food category. However, it is noteworthy that four out of seven medicinal plants that were not shared with the food category are actually not perceived as foodstuff, and the remaining three (i.e., *Lavandula angustifolia* Mill., *Matricaria chamomilla* L. and *Tilia* sp.) are actually perceived as foodstuff, although informants did not report them as such. Similarly, among the 22 ornamental plants not shared with the food category, only four are considered as foodstuff (i.e. *Lavandula angustifolia* Mill., *Primula* sp., *Rosa canina* L. and *Viola* sp.). Of the plants mentioned exclusively in the food category, almost 50% could also be used for medicinal purposes, yet the informants did not identify these

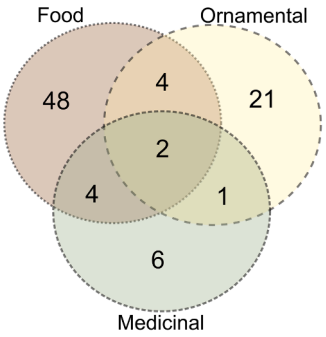

Fig. 4. Venn diagram reporting the overall number of plant species emerged from the survey in the food, medicinal and ornamental categories. The diagram was graphically elaborated using the freely accessible web tool https://bioinformatics.psb.ugent.be/webtools/Venn/.

uses. These findings suggest that urban foragers in Rimini are better at recognizing edible plants than medicinal ones, or that they are unaware of the medicinal properties of plants. In this anthropized context, respondents primarily recognize edible plants, demonstrating a more limited awareness of medicinal species. This may be due to residents' tendency to rely on conventional remedies for health issues, which has led to a gradual erosion of traditional knowledge regarding the medicinal use of plants. Souviney et al. (2024) reported similar results in a survey carried out in a peri-urban area close to Padua (Italy), where only a few participants indicated the use of some plants for medicinal purposes.

Lavandula angustifolia Mill. and *Urtica dioica* L. emerged as the most versatile species, being cited in four different use categories each. Lavender (*L. angustifolia*) is used for domestic, medicinal, repellent and ornamental purposes. In other Italian ethnobotanical studies, the domestic and repellent uses are often reported together as lavender sachets are traditionally used to perfume wardrobes while repelling moths and protecting stored clothing (Chiocchio et al., 2024). In the present study, however, only one informant cited this combined use, while six others referred to sachets exclusively for their domestic function of perfuming clothes. These findings suggest that knowledge of the repellent use of lavender is declining among urban foragers and that its use is now limited to domestic purposes with little awareness of its traditional role as a moth repellent.

Nettle (*U. dioica*) is mentioned for its food, medicinal, repellent and agro-pastoral uses, as already reported in other Italian ethnobotanical surveys (Chiocchio et al., 2024) highlighting its cultural significance for Rimini citizens.

4.4. Citizen science approach

The citizen science approach adopted in our ethnobotanical survey showed good agreement and consistency in the demographic composition of the sampled informant populations over the two-year survey, with similar age and gender distributions. This suggests that the approach was effective in capturing the observed population pattern. The number of informants interviewed in this study is comparable to, and in several cases slightly higher than, the number reported in other studies (Landor-Yamagata et al., 2018; Schunko and Brandner, 2022; Souviney et al., 2024). Research conducted in urban and peri-urban contexts often relies on moderate sample sizes, reflecting the qualitative and knowledge-oriented nature of these investigations, as well as the practical constraints associated with conducting fieldwork in public spaces. In this respect, the sample size achieved over the two-year period is particularly noteworthy, given that Rimini is a medium-sized city, and that data collection during the first survey year was partially affected by restrictions related to the pandemic, which limited social interactions and access to potential respondents.

However, some limitations and critical issues regarding data management emerged during the discussion with students after the interviews. In both years, interviewers observed that foragers tended to avoid spending much time on face-to-face interviews or responding to survey questions. This could be related to the so-called "interviewer effect", i.e., the informants' perception of the interviewers' young age, or to the interviewers' inexperience in managing specific social interactions (Friedel, 2020). Although no statistically significant differences were observed in the occurrence of incomplete responses across gender and age groups, the data reveal a tendency for male respondents, as well as those in the youngest and oldest age groups, to provide incomplete survey information. While this pattern did not reach statistical significance within the present sample, it could become relevant in studies involving larger populations. Therefore, when applying citizen science approaches to the collection of ethnobotanical information, this issue should be carefully considered in order to minimize potential biases in the data collection process and, consequently, to ensure the overall quality and reliability of the data.

Moreover, although the students were instructed to approach all park users, they may have been more inclined to approach individuals from similar socio-cultural backgrounds unconsciously. As the interviewers were recruited from two academically oriented "selective" high schools ("licei"), rather than from vocational, technical, or other types of secondary education, this may have influenced the composition of the sample, potentially leading to an overrepresentation of respondents with similar educational or cultural orientations. Biases in social perception can emerge directly from the structural properties of social networks, rather than solely from individual cognitive or motivational factors. In particular, network features such as homophily and asymmetric patterns of social connections can lead individuals to systematically over- or underestimate the presence of certain social groups within their immediate environment (Lee et al., 2019). Applied to our study, it is not possible to exclude that the social background, age, and positionality of interviewers may have influenced access to respondents and shaped sampling processes, potentially resulting in the overrepresentation of socially proximate groups, even in the absence of intentional selection. Nevertheless, the interviewed populations were remarkably similar across the two years, suggesting that the data collection method is robust. Future research should aim to involve citizen scientists from more diverse socio-cultural and educational backgrounds, including vocational and technical schools as well as community-based groups. This would help mitigate potential sampling biases, improve the representativeness of the data, and allow for a more robust validation of the observed patterns.

While the citizen science approach proved effective in capturing a broad overview of forage plant uses, the study was designed to prioritize the identification and circulation of commonly shared knowledge in an urban setting. More fine-grained ethnobotanical details, such as specific preparation methods, plant parts used, and recipes, were only partly addressed in this study, but they can be better addressed in future, targeted studies building on this initial proof-of-concept.

5. Conclusions

This ethnobotanical study was conducted using a citizen science approach, involving high school students as co-researchers, in an urban public park in Rimini, Italy. It provides insight into local and traditional plant knowledge and highlights the willingness of foragers to engage in safe practices. Our findings reveal that the majority of respondents favoured foraging in an urban public park, emphasizing the importance of this practice in preserving cultural traditions and local knowledge about plant resources.

The study also highlights the intergenerational nature of foraging, also in an urban park, which can be a valuable means of fostering connections between younger and older generations. This would promote the preservation of traditional knowledge about the use of plants and

foster valuable intergenerational bonds. Furthermore, our study emphasizes the significance of wild plants, particularly those associated with traditional cuisine, as carriers of traditional knowledge. These plants play a pivotal role in reinforcing cultural identity by fostering social interaction and knowledge sharing within the community. Addressing the barriers to urban foraging identified in this study in a way that is guided by community needs would promote the full realization of these ecosystem services and make them more easily accessible to people living in urban areas. Looking ahead, it is crucial that the scientific community assesses and quantifies the benefits of removing such barriers. This would provide robust evidence of how these actions can foster urban foraging practices and reinforce an equitable access to the ecosystem services, ultimately supporting the well-being and resilience of urban communities. Pilot studies demonstrating these benefits could encourage policymakers and local communities to recognize the positive implications of urban foraging, thereby fostering a cultural shift in how this practice is perceived. Policymakers could achieve significant strides towards wider recognition of foraging by implementing a two-pronged approach. Firstly, they could act directly by improving the planning and management of urban green spaces, creating dedicated foraging areas and implementing more favorable regulations. Secondly, they could make these favorable interventions and regulations widely known to citizens and install regulatory signs identifying suitable areas and permitted/prohibited activities.

Although the relationships explored in this study did not reach statistical significance, the observed trends offer valuable insights into the underlying patterns of urban foraging practices. Age, gender and mode of learning emerged as variables that may influence attitudes towards foraging in urban parks and data completeness. These factors warrant closer attention in future research. Studies with larger and more diverse samples could build on these preliminary findings to test their statistical robustness and examine their implications for urban ethnobotany and access to ecosystem services.

CRediT authorship contribution statement

Lorenzo Marincich: Writing – original draft, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Sonia Fabbrocino:** Supervision, Methodology. **Roberto Mandrioli:** Writing – review & editing, Supervision. **Fabiana Antognoni:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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Declaration of Competing Interest

Authors declare no competing interests.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2026.129443.

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