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Foraging Routine of Two Common Urban Birds on Berries of Exotic *Livistona chinensis*: A Winter Supplement in an Urban Landscape

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Abstract: Chinese Fan Palm, *Livistona chinensis*, was introduced as an ornamental plant towards the end of the nineteenth century in Pakistan, and since then, it has been used as a popular plant in urban landscaping. It dominates the green belt of parks, recreational gardens and road verges in Lahore, Pakistan. Recent trends in the plantation of fast-growing palm species and other exotics have replaced *L. chinensis* in urban landscaping. In this study, observations made on the daily routine of foraging of *L. chinensis* berries by two common urban birds, the red vented bulbul (*Pycnonotus cafer*) and the house crow (*Corvus brachyrhynchos*), showed that their consumption of berries peaked in December and January, but the duration of foraging was shown to be longer in house crows as compared to red vented bulbuls. This period of consumption corresponds to the time when the pulp of the berries has become soft, and during this period, no other fruits are available in the urban landscape. Nutrient analysis showed that the pulp of the ripened berries is a rich source of nutrients, and these berries are providing an ideal winter food to counter the increased energetic demands experienced by urban birds during the coldest part of the year, thus helping birds avoid the risk of starvation. This dietary intake of berries by birds also provides a rationale to popularize *L. chinensis* as an essential component of the planting palette of the urban landscape. This research can be considered as starting point for broad public support to improving landscape planning for managing nature in cities.

Keywords: exotic berries; urban landscape; winter food; nutrient source; urban birds

Citation: Khan, A.U.; Dad, F.P.; Hasnain, R.; Sharif, F.; Mansoor, A. Foraging Routine of Two Common Urban Birds on Berries of Exotic *Livistona chinensis*: A Winter Supplement in an Urban Landscape. *Sustainability* **2023**, *15*, 14521. https://doi.org/10.3390/su151914521

Academic Editors: Jitka Fialova and Jan Łukaszkiewicz

Received: 19 June 2023
Revised: 24 August 2023
Accepted: 5 September 2023
Published: 6 October 2023

1. Introduction

Livistona chinensis, the Chinese fan palm, is native to southern Japan, Taiwan, south-eastern China, and Hainan [1]. It is valued for landscaping and cultivated throughout the world in tropical and temperate climates [2–4] and is semi-naturalized in marsh forests of South Africa [5,6]. A survey carried out in Lahore revealed that *L. chinensis* produces new inflorescences in April and mature fruits are accessible to birds from October until April, and it generally produces inflorescence in alternate years [7]. Studies on the chemical composition of *L. chinensis*' berries showed that it has vitamins, fatty acids, flavonoids, amino acids, steroids and phenolics. Its extract contains antioxidant constituents and exhibits antiproliferative and antiangiogenic aspects, and it is used in traditional medicine to treat cancer [3,8–15]. *L. chinensis* is also known to enhance wildlife quality in urban landscapes. Large increases in the populations of birds, including bulbuls; two species of magpie, the red billed blue magpie and the Eurasian magpie (*Urocissa erythrorhyncha* and *Pica pica*); and the Asian koel (*Eudynamys scolopacea*) were reported during the winter periods after the large-scale introduction of *L. chinensis* in Hong Kong [16,17].

L. chinensis was introduced in Pakistan toward the end of the nineteenth century and, like in other regions of the world, was mainly used for decorative purposes. It

remained a popular plant in metropolitan centers from coastal regions to the foothills of the Himalaya. It covers two native plant formations of the region: tropical thorn forests and scrub forests [18]. It was noticed that in Lahore, two common urban birds, the red vented Bulbul (*Pycnonotus cafer*) and the house crow (*Corvus brachyrhynchos*), commonly feed on the large crop of the fruit of *L. chinensis* from November to March; this is a period which coincides with winter months [19]. Both birds are considered common free-living birds in cities in southeast Asia [20]. The red vented bulbul is a songbird; its calls include a variety of chirps and whistles, and in folklore, it is connected to native thorn forest species, *Salvadora oleoides, Salvadora persica* and *Capparis decidua*, which provide them a habitat throughout the year [18,21]. Red vented bulbuls eat a wide range of foods, ranging from fruit to seeds, nectar, small insects and other arthropods and even small vertebrates. After the advent of the irrigation system, the natural vegetation of the Indus flood plains was exterminated, and presently, it is dominated by introduced species, mostly from the tropical forests of India [21,22]. The red vented bulbul, being frugivorous, easily switched their diet to the introduced species [23] and this ability to supplement their diet is probably the reason why they have been successfully introduced in so many other countries in the world. Recently, there have been increasing concerns about its decline due to the rapid pace of urbanization [24].

The house crow is regarded as an invasive species [25] and its population is particularly large, especially in areas with high human populations. They are highly opportunistic birds, and given their omnivorous diet, can survive on nearly anything edible. These birds can be seen near marketplaces and garbage dumps, foraging for scraps and feeding on carcasses [26]. Their routine diet in an urban environment has a harmful effect on them due to lethal alkaloids and other toxins, which is considered to be responsible for the decline of many other species in cities [27,28].

In Lahore, Pakistan, *L. chinensis* was popularly used in landscaping for over a century; almost all old gardens and parks in the city have boulevards and boundaries dominated by the fruit-bearing trees. Recent trends in landscaping have favored fast-growing palm species (*Bismarkia nobilis*, *Roystonea regia* and *Washingtonia filfera*) and other exotic species, and this shift in urban landscaping is reflected in new gardens which are devoid of *L. chinensis* [7]. Although it has been a popular horticultural plant in Pakistan for more than a century, still, very little information is available in the context of its importance as food for wildlife, as reported in other countries in the world. No research has been carried out on this aspect, and thus, people are unaware of its value; therefore, it is losing ground to other species. Moreover, it has been observed that during spring and summer, the diet of these two common urban birds consists of a variety of abundant, protein-rich insects, flowers and fruits. But during winters, unlike in other temperate countries [29–32], the city is devoid of winter berries to sustain them through the season.

Landscape decisions made by urban planners are generally motivated by values and preferences resulting in the low abundance and diversity of native vegetation. In some cases, they accommodate residents' opinions, like planting exotics for birds instead of native plants, and therefore, their management strategies are focused on the assumption that there will be clear benefits for birds [33–36]. This is probably the reason why bird foraging behavior in urban areas does not discriminate between native and urban plant and bird species [35,37–41]. Recent research indicates that some introduced species have assumed the role of ecosystem services that were previously provided by native species that have declined or disappeared from an area [42–45]. This is the reason why the terminology of native and non-native species is losing much of its intended meaning in the fields of conservation and restoration ecology [46,47].

The introduction of *L. chinensis* in Hong Kong clearly illustrates how it can quickly adjust to new environments, and in Hong Kong, its berries have resulted in an increase in the bird population [16,17]. Although *L. chinensis* dominated the urban landscape in many countries in the world for more than a century [48], little research is available on its contribution as food for wildlife. Previous work suggested [19] that only two birds, the red

vented bulbul and the house crow, locally feed on its berries, and their number increased with the severity of the winter; therefore, we thought it would be interesting to carry out a preliminary investigation on their foraging routines to highlight their dependencies on the berries. We highlight this plant's contributions, in terms of its berries, as energy-rich food in winter for two common urban birds, with the added advantage of re-popularizing the species in urban landscaping in the South Asian region.

2. Methodology

2.1. Observations Made on Foraging Routine of the Birds

Since this was a preliminary study, the following methods were adopted to analyze the foraging behavior of the red vented bulbul and the house crow: A survey was conducted to select a tree for detailed observation on a lawn with 20 trees, with all of them being more than sixty years of age. It was generally observed that trees located singly in an open location seemed to be more popular with the birds as compared to understory trees. The tree selected for observation, apart from being the most popular tree with the birds, had the added advantage of having its berries parallel to the height (4 m) of a balcony from which foraging habits could be more clearly observed. The number of birds feeding on the berries was counted at regular intervals from a tent made on the balcony. Observations were noted for ten minutes after an interval of half an hour in the forenoon between 8 a.m. and 12 a.m. and in the afternoon between 2 p.m. and 5 p.m. Observations were recorded four times for five days from November 2018 to March 2019.

Furthermore, the portion of pulp consumed from the berries was estimated by collecting and categorizing the foraged pulp of berries into categories during the above-mentioned observation period: at weekly intervals, as described for the numbers of birds foraging on berries. A tray (0.45 × 0.35 m) was kept under the tree, and the berries were categorized, on the basis of the portion of pulp eaten by the birds, into three categories: Category A (0–5%: rarely consumed); Category B (11–50%: consumed); and Category C (51–100%: consumed). In addition, the number of berries consumed by house crows was estimated by counting droppings on the entire pavement (70 m × 5 m) around the lawn at weekly intervals with a similar pattern as described for the number of birds foraging on berries, except that an additional reading was taken in late March as the number of droppings indicated an extension in the house crows' duration of foraging. A one-way ANOVA was applied to determine the significance of the difference in the foraging routine of birds during the winter months. Linear regression was used to analyze and compare the trend of the forage routines of both birds. All analyses, including the mean average and standard error, were applied using SPSS (Version 16).

2.2. Nutrient Contents in the Pulp

The concentrations of the following nutrients in the pulp of berries collected in January were determined using various methods: Mg and Ca [49]; phosphorus, potassium, manganese, zinc, copper, and sodium [50]; and boron [51]. The moisture content of the pulp was determined by drying it at 130 °C. The ash content was determined using a Muffle furnace (sigma2/1500) at 550 °C, and the fiber content was determined using an electro mantle. The protein content was determined via the Kjeldahl method [52], fats using Soxhlet apparatus (Cat # 0500), as well as the lipid content [53]. The percentage of carbohydrates was estimated using the following formula:

$$\%\ Carbohydrate = 100 - (\%\ moisture + \%\ ash + \%\ Protein + \%\ Fat\ \%\ Fiber) \quad (1)$$

Energy was estimated using the following formula:

$$Energy\ (calories) = 4\ (\%\ Protein) + 9\ (\%\ Fat) + 4\ (\%\ Carbohydrate) \quad (2)$$

3. Results

The results demonstrated that the number of birds foraging on berries started to increase in late November, and it reached its peak in January and then gradually declined toward March, which also corresponded to a decline in the number of berries on the trees. It was observed that birds generally started to feed after sunrise and continued to forage at a steady rate and reached their peak before dusk. Both species generally came in separate groups, but occasionally, solitary birds or a few birds of the two species were seen feeding together (Figure 1a–d). It was also noted that foraging was generally more popular in the afternoon as compared to morning time. The results of the ANOVA (Table 1) and the trend of linear regression (Figure 2) show that the statistically significant decline in the number of red vented bulbul feeding on berries was more abrupt as compared to that of house crows, which continued feeding on them until the end of March.

(**a**)

(**b**)

Figure 1. *Cont.*

(**c**)

(**d**)

Figure 1. (**a**). Red vented bulbul foraging on the berries. (**b**). Red vented bulbuls and house crows together on the tree. (**c**). Crow swallowing the berries. (**d**). Flocks of house crows feeding on berries.

Table 1. Foraging routine of birds during the winter months.

Observation	House Crow		Red Vented Bulbul	
	Forenoon	Afternoon	Forenoon	Afternoon
28 November–5 December	2.83 ± 0.57	2.66 ± 0.62	2.16 ± 0.67	3.33 ± 0.33
30 December–6 January	4.83 ± 0.70	7.16 ± 0.98	4.16 ± 0.87	4.83 ± 0.70
1–7 February	6.5 ± 0.76	9.9 ± 1.25 *	5.03 ± 0.70	7.03 ± 0.49 *
25 February–3 March	2.67 ± 0.61	4.5 ± 0.66	0.83 ± 0.30	0.67 ± 0.33

* Significance $\leq$ 0.05.

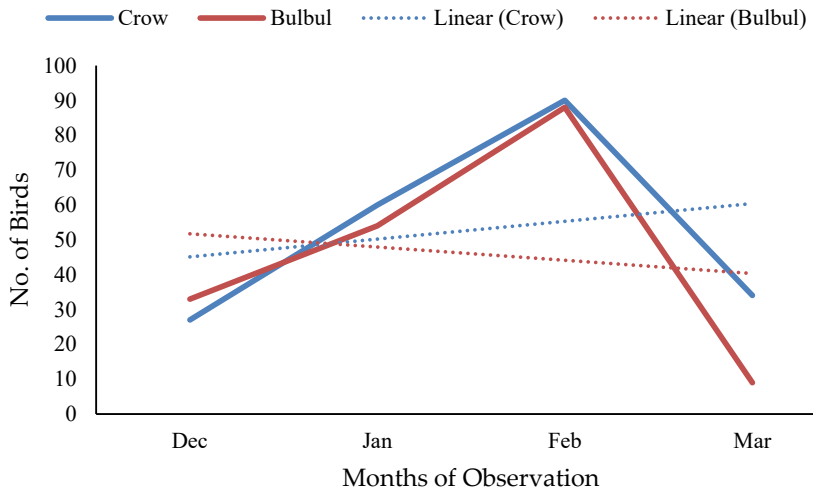

Figure 2. Foraging trends of the two common urban birds on the berries during winter.

It was also observed that the red vented bulbuls foraged on the pulp, whereas the house crows were observed swallowing entire berries most of the time, and their droppings were in the form of seeds, which were frequently seen scattered on the pavements (Figure 3). The number of fallen berries collected in the trays during the foraging season showed that the proportion of pulp consumed was smaller in early winter as compared to midwinter. Generally, the number of berries pecked upon increased from November to February, which is reflected in the gradual increase in the shift from category B to C (Table 2). This pattern of foraging corresponded with the number of red vented bulbuls foraging on berries, which generally reached its peak in January. This change in the category can be roughly related to berries being less palatable or hard to forage upon in November, and with an increase softness they became more palatable, and a greater proportion was consumed in December and January. Toward March, both the categories B and C declined, mainly because of a decrease in the number of red vented bulbuls foraging on berries. An increase in category A reflected the fact that ripened berries were easily detached from the plant when the house crows came to feed on them. The number of house crow droppings collected from the pavements also seemed to follow a similar pattern as that observed regarding the number of house crows feeding on berries, with the exception that it stretched until the end of March (Table 3).

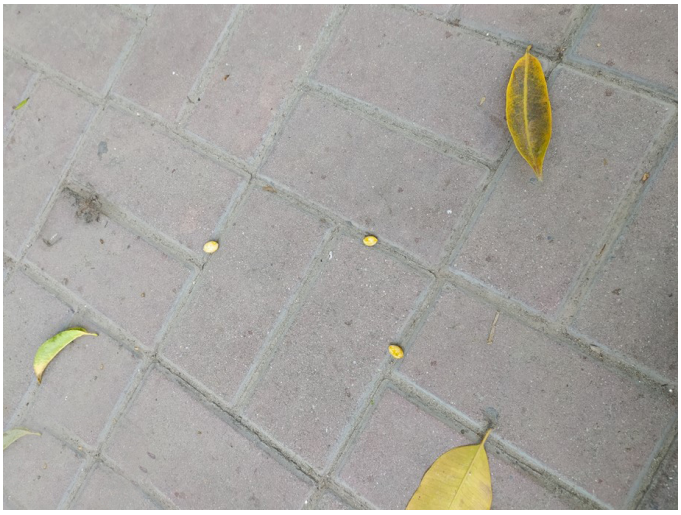

Figure 3. House crow droppings (seeds) on the pavements.

Table 2. Percentage of pulp eaten by birds.

Observation	Category A	Category B	Category C	Total
Percentage of *L. chinensis* Fruit Pulp Consumed by Bird	**0–5%**	**6–50%**	**51–99%**	
28 November–5 December	29	99	22	150
30 December–6 January	60	165	178	413
1–7 February	95	191	219	505
25 February–3 March	198	91	101	380

Table 3. Numbers of house crow droppings collected from pavements from December to March.

Observation	House Crow Droppings (Mean ± S. E)
28 November–5 December	3.6 ± 0.59
30 December–6 January	8.4 ± 0.50
1–7 February	14.8 ± 1.06
25 February–3 March	17.4 ± 1.02
20 March–27 March	7.8 ± 0.73

The nutrient content of the pulp of berries at the peak of foraging season showed 0.60% protein, 4.60% fats, 7.54%, moisture, 7.60% ash and 30.8% fibers, and the estimated value of carbohydrates was 48.86%, and energy was 239.24 calories. The percentage of lipids in the pulp of ripened berries was in the following order: oleic acid (54%), palmitic acid (31.9%), linoleic acid (6.5%), gadoleic acid (2%), erucic acid (2%), behenic acid (1.1%), myristic acid (0.9%), (0.6%), arachidonic acid (0.5%), linolenic acid and stearic acid (0.5%). The content of micronutrients was in the following order: iron 422.12 ppm, potassium 196.0 ppm, calcium 170 ppm, phosphorous 89.34 ppm, sodium 32.0, magnesium 21.6 ppm, zinc 10.21 ppm, copper 12.85 ppm and boron 2.93 ppm.

4. Discussion

The results clearly showed that the visits of the birds for foraging berries began toward the end of November. The beginning of the visits corresponded with the ripening of berries and the arrival of winter and continued until March. They represented the arrival of spring and the ripened berries falling off the tree. This trend of foraging can also be linked with the increasing scarcity of alternative food with decreasing winter temperatures. This long feeding duration of the two common urban birds on berries during the coldest month of the year also means that the berries provided good-quality food to enable them to survive the stress of cold weather. In many parts of the northern hemisphere, insectivorous birds change their diet to energy-rich berries when the weather turns cold. Other foods the birds feed on become scarce to keep their body temperatures up so they do not freeze to death [54,55]. In the absence of natural flora in the urban landscape [21,22], many birds in the city have adapted to forage on fruits of exotics to obtain the energy they need to survive the stress of hot [56] and cold weather [7]. The chemical composition of berries can be affected by the climatic conditions of the area they grow in and the time of harvesting. In Lahore, Pakistan, where December and January were the coldest months in the city [18], the content of essential elements and fatty acids of *L. chinensis* berries in this period showed that they were a rich source of fatty acids and mineral nutrients. A comparison with date palms (*Phoenix dactylifera* L.) showed that they contained similar nutrients and carbohydrates but they had higher fat content and dietary fiber as compared to date palms [57]. Edible wild plants with fatty acids and nutrients [58–64], popularly consumed by mankind, have been considered essential for normal growth and development and have played an important role in the prevention and treatment of disease [65,66]. The comparison of the results of this study with the above-reported results showed that *L. chinensis* berries had a notably higher concentration of oleic acid (54%) and iron content (422.12 ppm) as compared to other wild berries and fruits, indicating that birds feeding on berries with high nutritive and

hematinic values could function optimally by reducing the risk of starvation and disease during winter.

The study also reflected on differences in the timing and pattern of feeding between the two species. It appeared that red vented bulbuls abandon feeding on pulp with the arrival of spring (early March), which could be associated with the availability of spring food. Meanwhile, house crows continued feeding throughout spring until all the berries were shed (April). Their long feeding duration on the berries indicated that this is the preferred diet for house crows as compared to red vented bulbuls, or it could be related to house crow's metabolism, preferring lipid-rich berries because of their slower food passage rates [30,67]. Or, it may be because, for red vented bulbuls, more alternative food was available in early spring, or it may be because red vented bulbuls avoided feeding on less juicy berries, which easily detach when pecked upon. Apart from producing energy-rich berries during the coldest month of the year, the plant has the additional advantage of the profuse production of berries; a single *L. chinensis* produces approximately 25,000 berries, acting as a living bird feeder to provide quality food to help birds survive the stress of cold weather. Studies on fruit abundance [29,68–70], showed positive correlations between resource and vertebrate abundances, which are an important aspect to consider from an ecological and evolutionary point, as it would help in designing landscapes in urban ecosystems which could promote fruit bird interaction. In addition to its wildlife and horticultural values, the palm has other attractive attributes, like a carbon sequestration ability (5.91 kg/year), the provision of nesting material for sparrows and the ability to attract pollinators when in bloom [7].

The daily foraging spells of birds in winter indicated how increasing energetic demands experienced by birds were met to counteract risks of starvation in a landscape devoid of winter berries. In fact, berries of this exotic species were a far better alternative as compared to the traditional feeding of birds on supplemental food or on urban waste and numerous other stresses, which they experience in urban centers [71,72], to get them through lean times. Most environments in populated areas of the world now contain both long-term residents and new arrivals [48], and it appears that this trend of a mixture of new and old species in environments will continue in the future, especially in countries where governments do not screen species coming into their countries.

This dietary intake of berries of *L. chinensis* represented an opportunity to improve the urban bird population's health via its inclusion as an essential component of the planting palette to support biodiversity in a large-scale urban landscape [73]. Present trends of the replacement of *L. chinensis* by other fast-growing species is an indicator that reflects that alternative sources of winter food for birds will be diminished in the future. This shows that a more pragmatic view needs to be adopted for species like *L. chinensis*, which has become established widely at the global level, regarding its replacement by other species in an urban landscape, where it has impacted both biotic and abiotic factors considerably.

5. Conclusions

In an urban atmosphere, human lifestyle manages to mitigate elevated levels of various chemical compounds in food and the atmosphere and nutritional information is increasingly available for the health benefits of numerous edible and domesticated wild plants for human wellbeing. Likewise, some urban birds are selecting alternative food to avoid the risk of being harmfully affected by deleterious impacts on their survival and reproduction. This work, by shedding light on daily foraging routines in two free-living birds on berries of an exotic horticultural plant, showed that their perceptions of risk are biased towards starvation avoidance in winter. This work can be used as a starting point for broad public support and as an emblem to improving landscape planning for managing nature in cities.

Author Contributions: Conceptualization and Supervision, Methodology, A.U.K.; Data curation, Writing—original draft F.P.D.; Formal Analysis, Resources, R.H.; Review and Editing, F.S. Formal Analysis, Writing—review & editing, A.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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