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Food-plant assemblage associated with *Pteropus medius* and *Cynopterus sphinx* (Chiroptera: Pteropodidae) in Kamrup, Assam, India

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Old World fruit bats (Pteropodidae) play important roles as seed dispersers and pollinators in tropical ecosystems. This study documented food plants associated with pteropodid bat feeding and characterized their botanical and ecological attributes in Kamrup District, Assam, India, between January 2022 and April 2025. A total of 76 food-plant taxa/entries, representing 42 genera and 25 families, were documented from indirect feeding evidence. The records included 24 locally recognized *Musa* spp. cultivar entries and 52 non-*Musa* botanical entries. Moraceae was the most represented non-*Musa* family, with nine entries, while *Ficus* was the most diverse non-*Musa* genus, with six entries. Fruits were the plant part most commonly associated with feeding, occurring alone in 43 entries (56.6%), followed by fruits and flowers in 24 entries (31.6%). Among fruit types, berries were most represented, with 36 entries (47.4%), followed by drupes, with 19 entries (25.0%). Native plants accounted for 57 entries (75.0%), while 54 entries (71.1%) were evergreen. Twenty-nine entries (38.2%) showed year-round flowering and/or fruiting, whereas 47 entries (61.8%) showed seasonal plant phenology. Chi-square analysis showed a significant association between plant origin and plant parts associated with feeding, whereas associations with fruit type and flowering/fruiting period were not significant. The study provides baseline information on food plants associated with *Pteropus medius* and *Cynopterus sphinx* in Kamrup and their botanical and ecological characteristics, and a basis for future species-specific and quantitative investigations of bat–plant interactions in the region.

Keywords: Assam, food plant characteristics, foraging ecology, fruit bats, plant phenology, plant use.

Los murciélagos frugívoros (Pteropodidae) desempeñan funciones importantes como dispersores de semillas y polinizadores en los ecosistemas tropicales. Este estudio documentó las plantas de las que se alimentan los murciélagos pteropódidos y caracterizó sus atributos botánicos y ecológicos en Kamrup, Assam, India, entre enero de 2022 y abril de 2025. Se documentaron 76 taxones/entradas de plantas alimenticias, pertenecientes a 42 géneros y 25 familias, a partir de evidencias indirectas de alimentación. Los registros incluyeron 24 entradas de cultivares de *Musa* spp. reconocidos localmente y 52 entradas no pertenecientes a *Musa*. La familia Moraceae fue la más representada, con nueve entradas, mientras que *Ficus* fue el género más diverso, con seis entradas. Los frutos fueron la parte vegetal más frecuente, presentes solos en 43 entradas (56,6%), seguidos de frutos y flores en 24 (31,6%). Las bayas fueron el tipo de fruto más representado (36 entradas; 47,4%), seguidas de las drupas (19; 25,0%). Las plantas nativas representaron 57 entradas (75,0%) y las perennifolias 54 (71,1%). Veintinueve entradas (38,2%) presentaron floración y/o fructificación durante todo el año, mientras que 47 (61,8%) mostraron fenología estacional. El análisis de chi-cuadrado mostró una asociación significativa entre el origen de las plantas y las partes vegetales asociadas con la alimentación, pero no con el tipo de fruto ni con el período de floración/fructificación. El estudio proporciona información de referencia sobre las plantas alimenticias asociadas con *Pteropus medius* y *Cynopterus sphinx* en Kamrup y una base para futuras investigaciones específicas por especie y cuantitativas.

Palabras clave: Assam, características de las plantas alimenticias, ecología de la alimentación, fenología vegetal, murciélagos frugívoros, uso de plantas.

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Bats (Chiroptera) are an important component of terrestrial ecosystems and exhibit considerable diversity in morphology, physiology, and feeding ecology (Jones *et al.* 2009; Kruskop 2021; Ramírez-Fráncel *et al.* 2022). They provide important ecosystem services, including pollination and seed dispersal, which contribute to plant regeneration and broader ecosystem processes (Fujita and Tuttle 1991; Kasso and Balakrishnan 2013; Guo *et al.* 2026). Bat–plant interactions are therefore important for understanding the ecological relationships between bats and vegetation and for documenting the plant resources associated with frugivorous and nectarivorous bats.

Pteropodidae, commonly known as Old World fruit bats, comprise species that utilize a diversity of plant-derived resources, including fruits, flowers, nectar, pollen, and leaves (Marshall 1985; Birt *et al.* 1997; Barclay *et al.* 2006; Aziz *et al.* 2021). The types and seasonal use of plant resources may vary among species and with resource

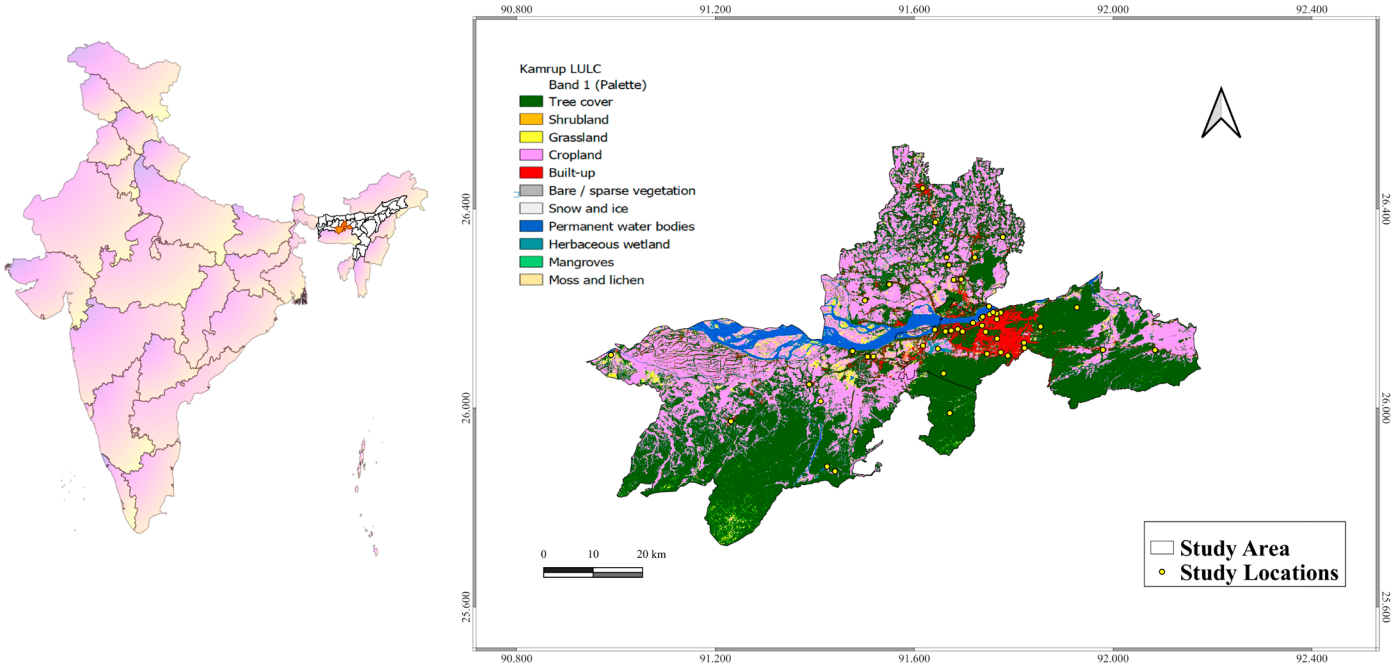


Figure 1. Map of the study area in Kamrup District, Assam, India, showing the surveyed locations. The inset indicates the location of Kamrup District within Assam and India.

availability. Recent studies in India have documented the use of different fruit and floral resources and variation in resource use across seasons (Dihora and Dodia 2023; Kumar and Elangovan 2025). Such variation highlights the importance of documenting plant resources associated with pteropodid bats within different geographic and ecological settings.

Globally, 1515 bat species have been identified, of which 204 belong to the family Pteropodidae (Sharma *et al.* 2025; Simmons and Cirranello 2026). India supports 135 bat species, including 12 pteropodid species (Sharma *et al.* 2025). In Assam, 39 bat species have been documented, including five pteropodid species: *Pteropus medius*, *Rousettus leschenaultii*, *Cynopterus sphinx*, *Cynopterus brachyotis*, and *Eonycteris spelaea* (Ali 2022). Within Kamrup District, 13 bat species have been reported, including the two pteropodid species *P. medius* and *C. sphinx* (Boro *et al.* 2018; Saikia 2018; Ali 2022). Studies in the district have also documented bat roosting habitats and their associations with tree characteristics and surrounding landscape features (Deka *et al.* 2026). These records provide a regional context for documenting plant resources associated with pteropodid bats.

Despite the ecological importance of pteropodid–plant interactions, information on their food plants in Assam remains limited. In Assam, Ali (2014) documented 51 food plants associated with *Pteropus giganteus* in the Lower Brahmaputra Valley, particularly in Dhubri District. However, comparable documentation of food plants associated with pteropodid bats in Kamrup District is lacking. Kamrup represents a heterogeneous landscape comprising agricultural areas, wetlands, forested and hilly tracts, and human-dominated areas. Recent studies have documented substantial land-use and landscape transformation in the Kamrup region associated with urbanization, including expansion of built-up areas and changes in agricultural and forest cover (Choudhury *et al.* 2023). Urban expansion and associated loss of roosting trees have also been identified as conservation concerns for *Pteropus giganteus* in Guwahati (Sharma and Rai 2020). These characteristics provide an important regional context for documenting plant resources associated with pteropodid bats.

The food-plant records documented in the present study therefore pertain to the pteropodid bats occurring in the study area. However, individual food-plant records could not be assigned retrospectively to either *P. medius* or *C. sphinx*, because species identity was not recorded with each feeding-remain observation. Accordingly, the present study describes the collective food-plant assemblage associated with these two species and does not infer species-specific dietary preferences or partitioning.

The present study therefore aimed to document the food plants associated with the two recorded pteropodid bats in Kamrup District, Assam, and to characterize the botanical and ecological characteristics of the documented food plants. The study considered plant parts associated with feeding, fruit type, flowering and fruiting period, taste, growth form, geographic origin, and conservation status. Food-plant evidence was obtained primarily from feeding remains and fibrous ejecta. The study provides baseline information on the food-plant assemblage of pteropodid bats in Kamrup and contributes to understanding the range of plant resources associated with their feeding ecology in the region. Specifically, the study asked which food plants were associated with pteropodid bat feeding in Kamrup and what botanical and ecological characteristics characterized these documented food plants.

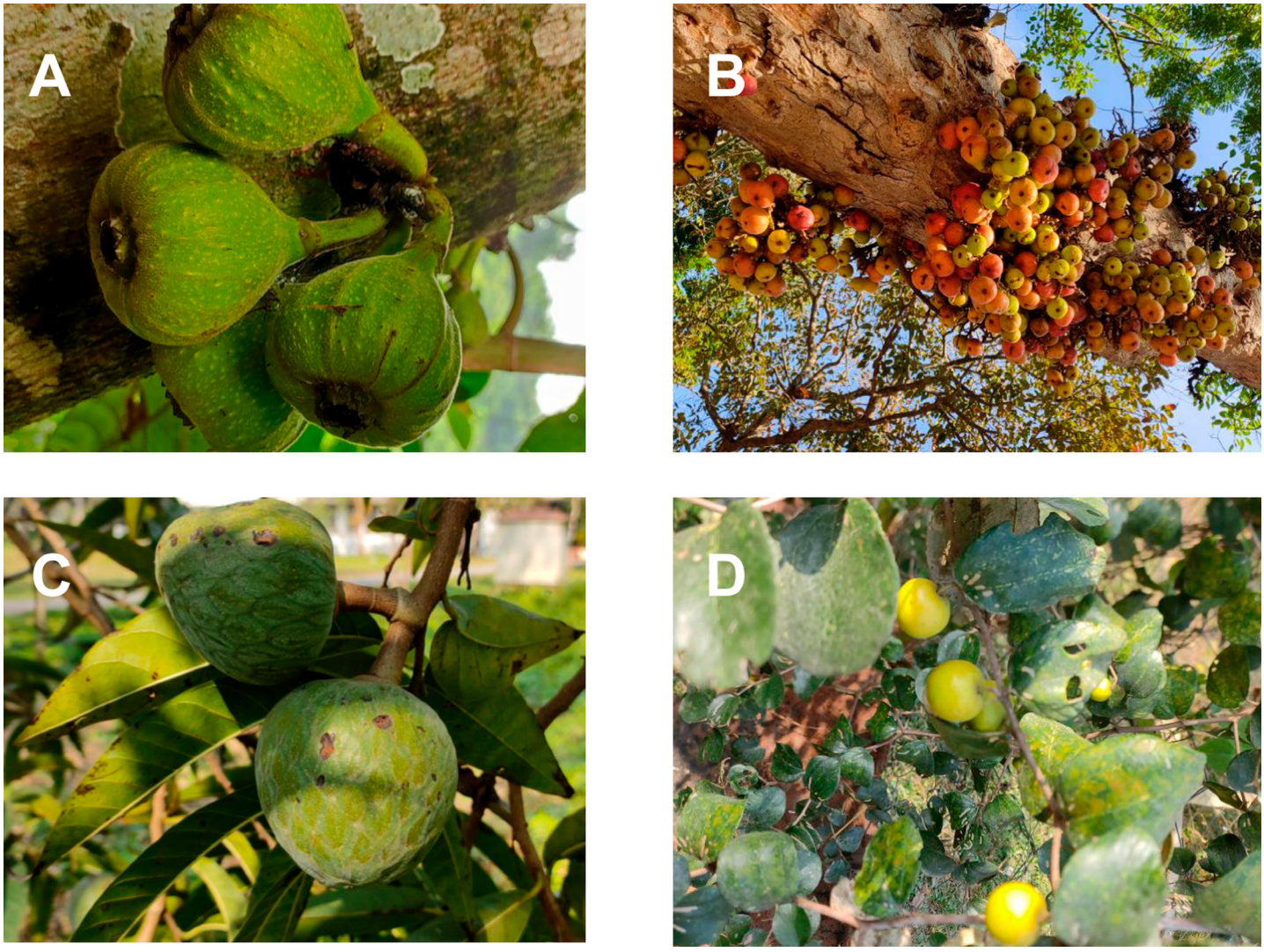


Figure 2. Photographic plate of documented food plants associated with feeding activity in Kamrup District, Assam, India. (A) *Ficus hispida*, fruit cluster, photographed on 4 August 2023; (B) *Ficus racemosa*, fruiting branch, photographed on 17 April 2022; (C) *Annona reticulata*, ripe fruits, photographed on 29 July 2024; (D) *Ziziphus jujuba*, ripe fruits, photographed on 11 August 2022.

Materials and methods

Study Area. The present study was conducted from January 2022 to April 2025 in Kamrup District, Assam, India. The district covers approximately 2,740.74 km^2 (Government of Assam 2025). The Brahmaputra River divides the district into two nearly equal portions (Government of Assam 2024). Kamrup District lies between 25°46' and 26°49' N latitude and 90°48' and 91°50' E longitude and is bounded by Udalguri and Baksa districts to the north, Meghalaya to the south, Darrang and Kamrup Metropolitan districts to the east, and Goalpara and Nalbari districts to the west (Government of Assam 2025). The vegetation includes hill sal forests, moist mixed deciduous forests, evergreen patches, secondary moist bamboo brakes, and secondary euphorbiaceous scrub. Representative plant species documented in these forest descriptions include *Shorea robusta, Lagerstroemia parviflora, Bombax ceiba, Schima wallichii, Chukrasia tabularis*, and *Albizia procera* (Champion and Seth 1968). The climate of Kamrup District is subtropical, with semi-dry summers and cold winters. The region receives approximately 1,500–2,600 mm of annual rainfall. Reported maximum temperatures range from 37–39°C, minimum temperatures from 6–7°C, and average relative humidity is approximately 75% (District Disaster Management Authority 2024).

Methods of Study. Field surveys were conducted once per week from January 2022 to April 2025, between 7:00 and 10:00 h. A total of 160 survey visits were conducted across the 50 sampling locations during the study period, to document food plants associated with pteropodid bats and characterize their botanical and ecological attributes. Sampling locations were selected using three approaches: (i) previous records from published literature; (ii) local inquiries with residents and other knowledgeable persons regarding locations where bats or bat-feeding activity had been observed; and (iii) active field searches and random selection to obtain broad spatial coverage (Figure 1; Supplementary Data SD1).

Food plants associated with the feeding evidence were identified using field observations, photographic records, and relevant botanical identification literature. Uncertain identifications were verified by a botanist/plant

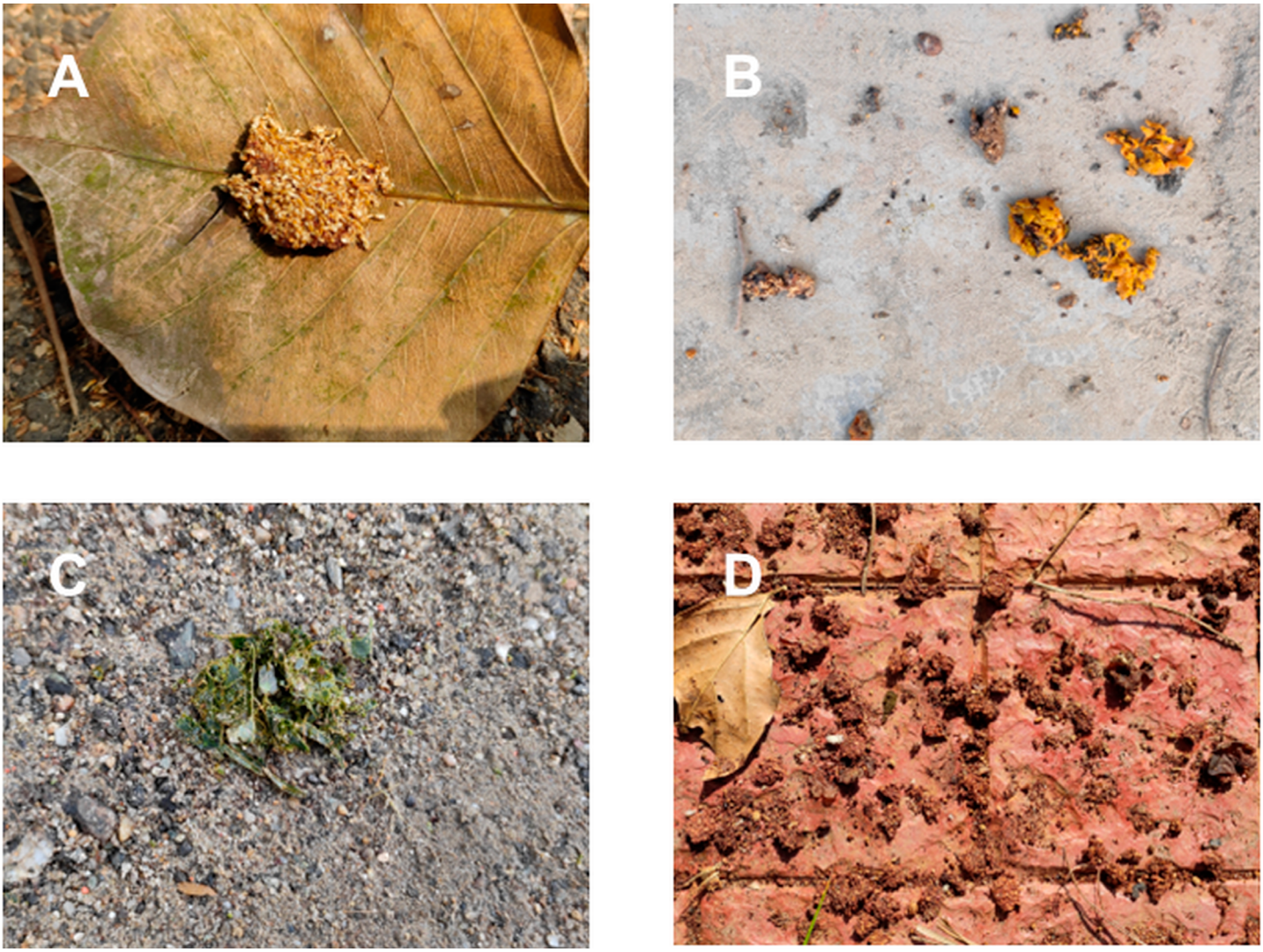


Figure 3. Photographic plate of feeding remains and fibrous ejecta collected from feeding sites in Kamrup District, Assam, India. (A) *Ficus racemosa*, fibrous fruit-pulp remnants, photographed on 2 June 2024; (B) *Ziziphus jujuba*, fibrous fruit-pulp remnants, photographed on 27 August 2022; (C) *Ficus religiosa*, partial leaf remains, photographed on 9 May 2023; (D) *Ficus religiosa*, fibrous fruit-pulp remnants, photographed on 15 June 2022.

taxonomist before inclusion in the dataset (Patiri and Borah 2007; Barooah and Ahmed 2014; Botanical Survey of India 2026; Centre for Ecological Sciences, Indian Institute of Science 2026).

Data Collection. During each survey, the sampling locations were systematically searched for characteristic fibrous bolus/ejecta beneath trees. The presence of characteristic bolus/ejecta was used as the criterion for identifying indirect evidence of bat feeding. Photographs of documented food plants were obtained during field observations (Figure 2). Partially consumed plant material associated with such bolus/ejecta was also recorded (Figure 3). Material attributable to natural fruit deterioration, fallen fruits without associated bolus/ejecta, or feeding by other animals was excluded from the food-plant records.

The collected material was used for field documentation and plant identification where applicable; no laboratory analysis of the feeding remains was undertaken. No bat feeding event was recorded during the surveys. All field observations and food-plant evidence were recorded by a single observer using the same field-search and recording procedure throughout the study period. Field observations and documentation were carried out using a digital single-lens reflex (DSLR) camera (Nikon D5300), binoculars (Nikon PROSTAFF P3 8×30), and a handheld Global Positioning System (GPS) navigator (Garmin eTrex 22x).

For each documented food plant, the plant part associated with feeding, fruit type, flowering and fruiting period, taste, growth form, geographic origin (native or exotic), and International Union for Conservation of Nature (IUCN 2025) conservation status were recorded. Flowering and fruiting periods represented the phenology of the plant and were recorded as plant characteristics rather than as the exact timing of bat feeding. Repeated records of the same plant species or cultivar were consolidated into one record. Identification was based on the diagnostic characteristics available from the intact or partially consumed plant material and associated photographic records; a separate reference collection of seeds or fibres from feeding remains was not established.

Data Analysis. Descriptive statistics were used to summarize the documented food-plant entries according to

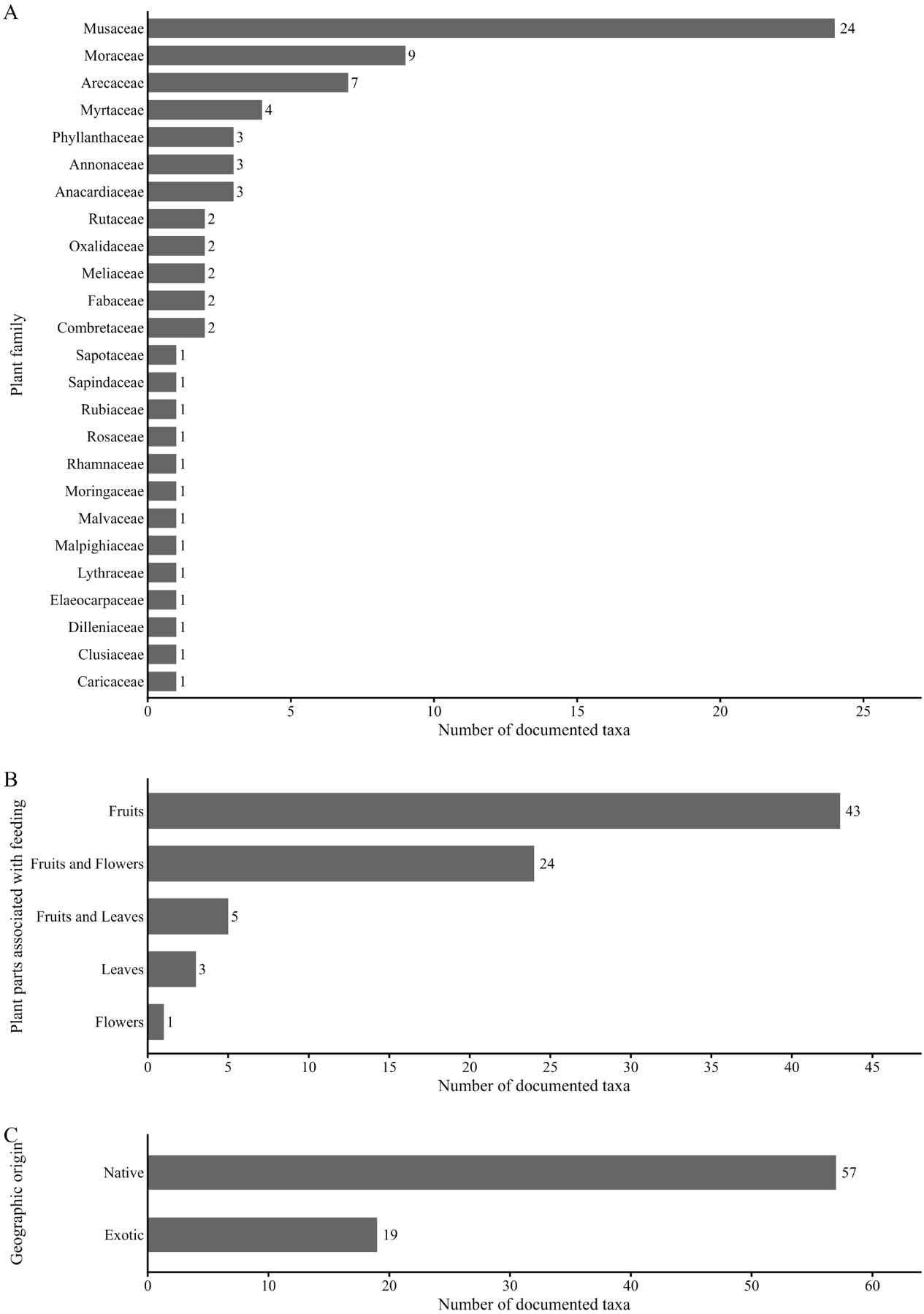


Figure 4. Characteristics of the documented food-plant taxa/entries associated with feeding activity of *Pteropus medius* and *Cynopterus sphinx* in Kamrup District, Assam. (A) Distribution according to plant family; (B) plant parts associated with feeding; (C) geographic origin categorized as native or exotic. Data are presented as the number of documented food-plant taxa/entries.

family, genus, plant parts associated with feeding, fruit type, flowering/fruiting period, taste, growth form, geographic origin, and IUCN (2025) conservation status. Frequencies and percentages were calculated for categorical variables. Associations between plant origin (native/exotic) and selected categorical characteristics, including plant parts associated with feeding, fruit type, and flowering/fruiting period, were examined using Pearson's chi-square test. Because some contingency tables contained low expected frequencies, *P*-values were estimated using Monte Carlo simulation with 10000 replicates. Multiple Correspondence Analysis (MCA) was used as an exploratory multivariate method to visualize associations among categorical plant characteristics, including growth form, fruit type, taste, plant parts associated with feeding, and plant origin. All statistical analyses were conducted in R version 4.3.1 (R Core Team 2023), with significance assessed at $\alpha = 0.05$. Maps and graphical representations were prepared using QGIS v3.28 (QGIS Development Team 2023) and Microsoft Excel (Microsoft Corporation 2021).

Results

A total of 76 food-plant taxa/entries, representing 42 genera and 25 families, were documented in association with feeding activity of the two pteropodid bat species recorded from Kamrup District, *Pteropus medius* and *Cynopterus sphinx*, during the study period. The records comprised 52 non-*Musa* botanical entries and 24 locally recognized *Musa* spp. cultivar entries. These records represent the collective food-plant assemblage documented in the study area. At the family level, Musaceae was the most represented, with 24 entries corresponding to locally recognized *Musa* spp. cultivars, followed by Moraceae with nine and Arecaceae with seven. Myrtaceae contributed four entries, while Anacardiaceae, Annonaceae, and Phyllanthaceae contributed three entries each. Combretaceae, Fabaceae, Meliaceae, Oxalidaceae, and Rutaceae each contributed two entries. Caricaceae, Clusiaceae, Dilleniaceae, Elaeocarpaceae, Lythraceae, Malpighiaceae, Malvaceae, Moringaceae, Rhamnaceae, Rosaceae, Rubiaceae, Sapindaceae, and Sapotaceae each contributed one entry.

At the genus level, *Musa* was represented by 24 entries, followed by *Ficus* with six and *Artocarpus* with three. *Phyllanthus*, *Terminalia*, *Spondias*, and *Averrhoa* each contributed two entries, while the remaining genera were represented by single entries (Figure 4A).

Fruits were the most frequently documented plant part, occurring alone in 43 entries (56.6%). Feeding evidence involving fruits and flowers was recorded for 24 entries (31.6%), fruits and leaves for five entries (6.6%), leaves alone for three entries (3.9%), and flowers alone for one entry (1.3%) (Figure 4B). The five entries associated with fruits and leaves included *Ficus benghalensis*, *F. racemosa*, *F. religiosa*, *F. curtipes*, and *Tamarindus indica*. A supplementary photograph shows *Pteropus medius* perched on *F. racemosa* in the study area (Supplementary Data Figure S1). Leaf-associated records also included *Eucalyptus* spp., *Moringa oleifera*, and *Erythrina variegata*, while flower-only feeding evidence was recorded for *Neolamarckia cadamba*.

In terms of geographic origin, 57 entries (75.0%) were classified as native and 19 entries (25.0%) as exotic (Figure 4C). Of the 76 documented food-plant entries, 49 (64.5%) were classified as cultivated and 27 (35.5%) as wild (Supplementary Data SD2). Eight fruit-type categories were recorded among the 76 documented food-plant entries. Berry-type fruits were the most common, comprising 36 entries (47.4%), followed by drupes with 19 entries (25.0%). Capsules and syconia (figs) each accounted for six entries (7.9%). Multiple fruits (syncarpia) accounted for four entries (5.3%), while aggregate fruits and legumes each represented two entries (2.6%). Hesperidium was represented by one entry (1.3%) (Figure 5A).

The taste characteristics of the documented food plants comprised 21 categories. "Sweet, creamy" was the most common category, represented by 24 entries (31.6%), followed by "sour, tangy" and "sweet, slightly tart," with eight entries (10.5%) each. "Bitter" was recorded for five entries (6.6%). "Sweet, juicy," "sweet, tropical," and "tasteless" were each represented by three entries (3.9%). "Bitter, astringent," "sweet, aromatic," "sweet, chewy," "sweet, fragrant," "sweet, nutty," "sweet, slightly tangy," "tangy, slightly sweet," and "sweet, tart" were each represented by two entries (2.6%). "Earthy, slightly bitter," "mild, slightly sweet," "slightly bitter," "sour, astringent," "sweet, custard-like," and "sweet, tangy" were each represented by one entry (1.3%) (Figure 5B). Of the 76 documented food-plant entries, 54 (71.1%) were evergreen and 22 (28.9%) were deciduous (Figure 5C). Regarding conservation status, 34 entries (44.7%) were classified as Least Concern (LC), whereas 42 entries (55.3%) were listed as Not Evaluated (NE) according to the IUCN (2025) status recorded for the respective plants (Figure 5D).

The documented food plants showed both year-round and seasonal flowering and/or fruiting periods. Twenty-nine entries (38.2%) had year-round flowering and/or fruiting periods, whereas 47 entries (61.8%) had seasonal periods. Among the seasonal categories, March–May was represented by 11 entries (14.5%), April–June by eight entries (10.5%), June–August by four entries (5.3%), May–July and March–June by three entries each (3.9%), while the remaining seasonal periods were represented by one or two entries each (Figure 6). Flowering and fruiting occurred across different months, with variation among the recorded plant species.

The association between plant origin and plant parts associated with feeding was statistically significant ($\chi^2 = 17.62$, d.f. = 4, $P = 0.0012$). In contrast, there was no statistically significant association between plant origin and fruit type ($\chi^2 = 12.63$, d.f. = 7, $P = 0.0723$). Similarly, plant origin was not significantly associated with the classification of flowering/fruiting period as year-round or seasonal ($\chi^2 = 3.14$, d.f. = 1, $P = 0.1034$).

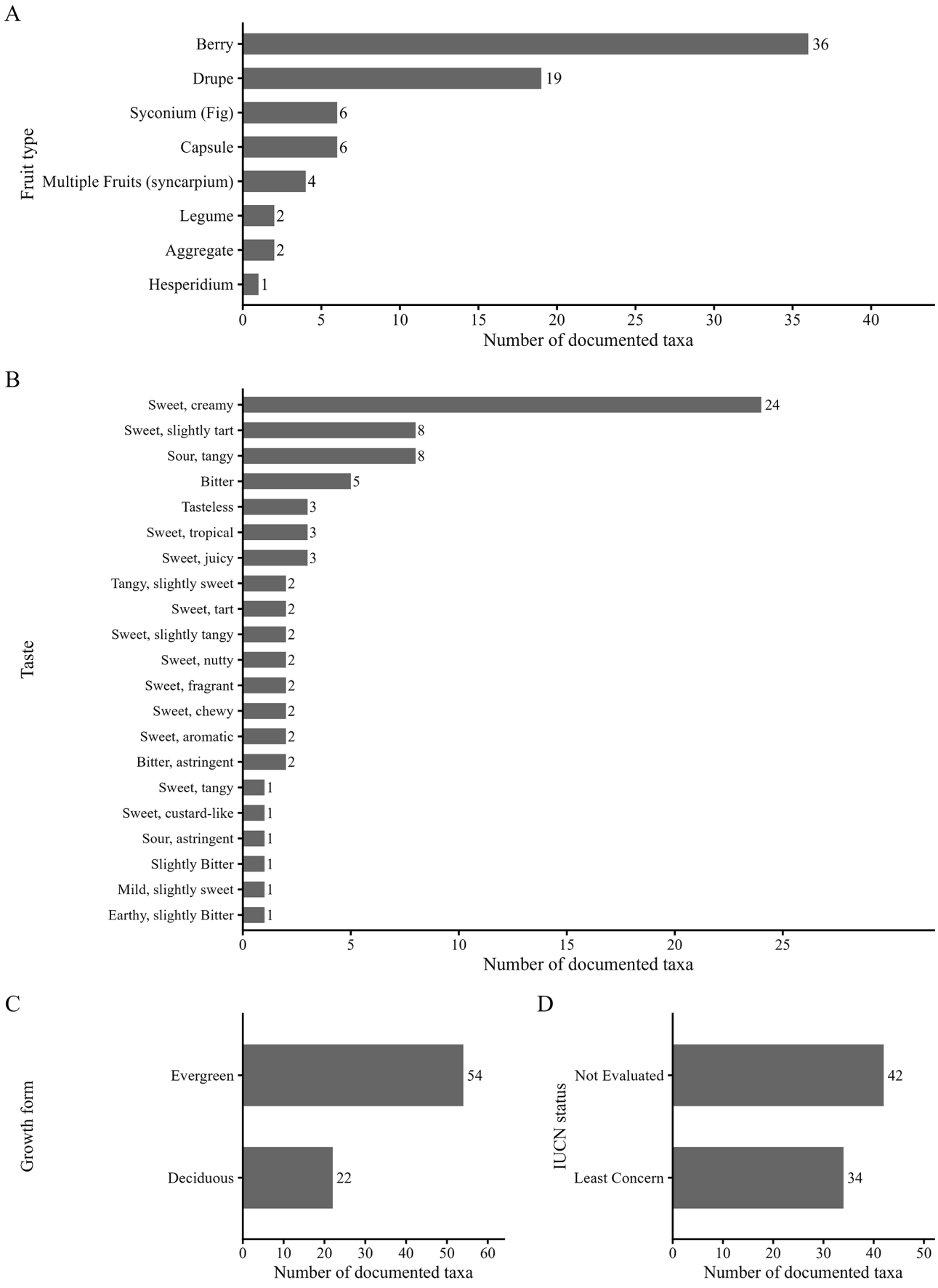


Figure 5. Characteristics of the documented food-plant taxa/entries associated with feeding activity of *Pteropus medius* and *Cynopterus sphinx* in Kamrup District, Assam. (A) Distribution according to fruit type; (B) taste categories; (C) growth form; (D) IUCN conservation status. Data are presented as the number of documented food-plant taxa/entries.

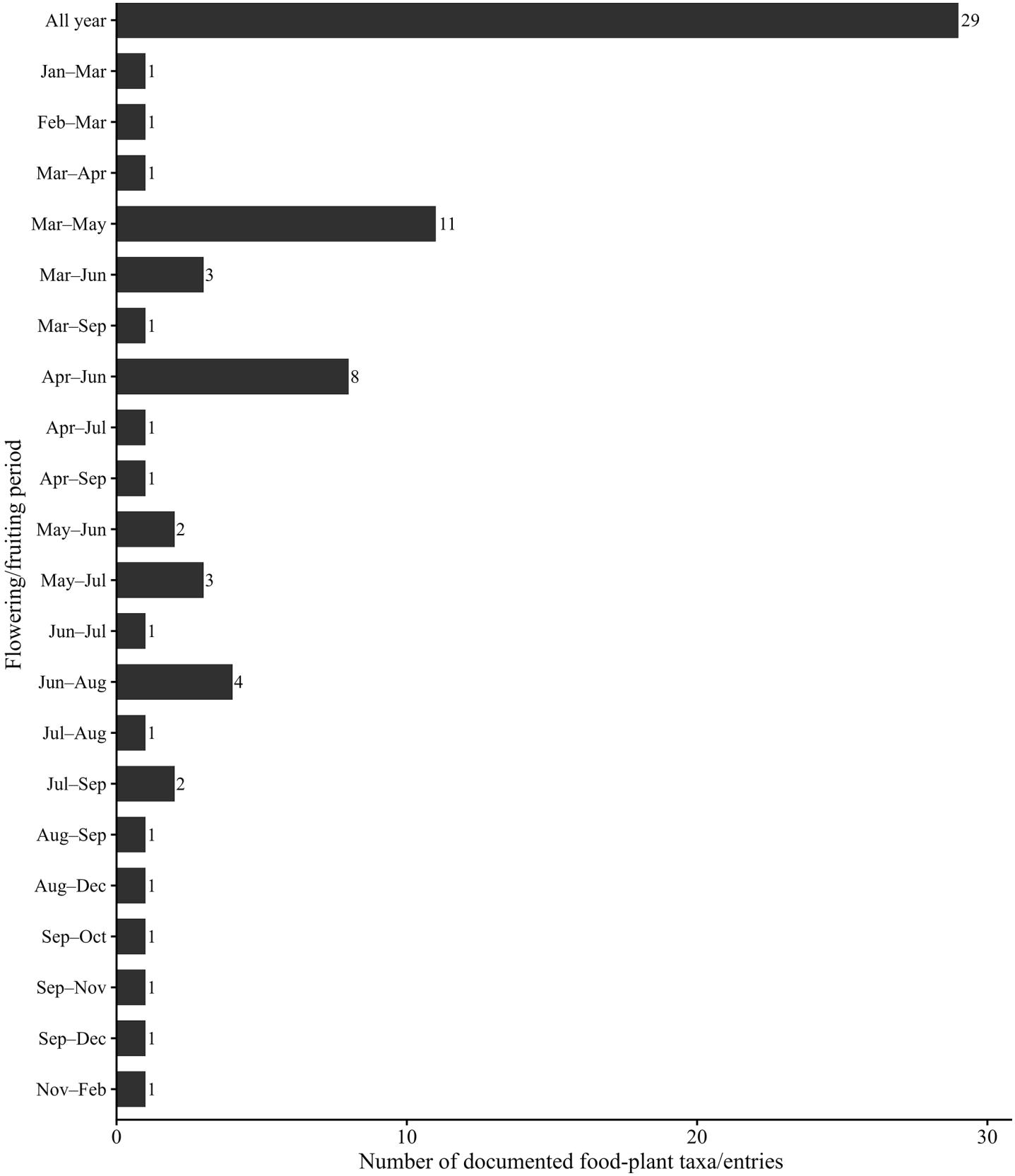


Figure 6. Flowering and fruiting periods of the documented food-plant taxa/entries associated with feeding activity of *Pteropus medius* and *Cynopterus sphinx* in Kamrup District, Assam. The figure shows the recorded flowering and/or fruiting periods of the plants, including year-round and seasonal categories. These categories represent plant phenology and do not indicate the exact timing or frequency of bat feeding.

Multiple Correspondence Analysis (MCA), based on growth form, fruit type, taste, plant parts associated with feeding, and plant origin, showed patterns of association among the documented food-plant characteristics (Figure 7). Native and evergreen plants were positioned closer to berry-type fruits and fruits-and-flowers feeding, whereas exotic and deciduous plants were positioned closer to drupes, capsules, leaves, and several taste categories.

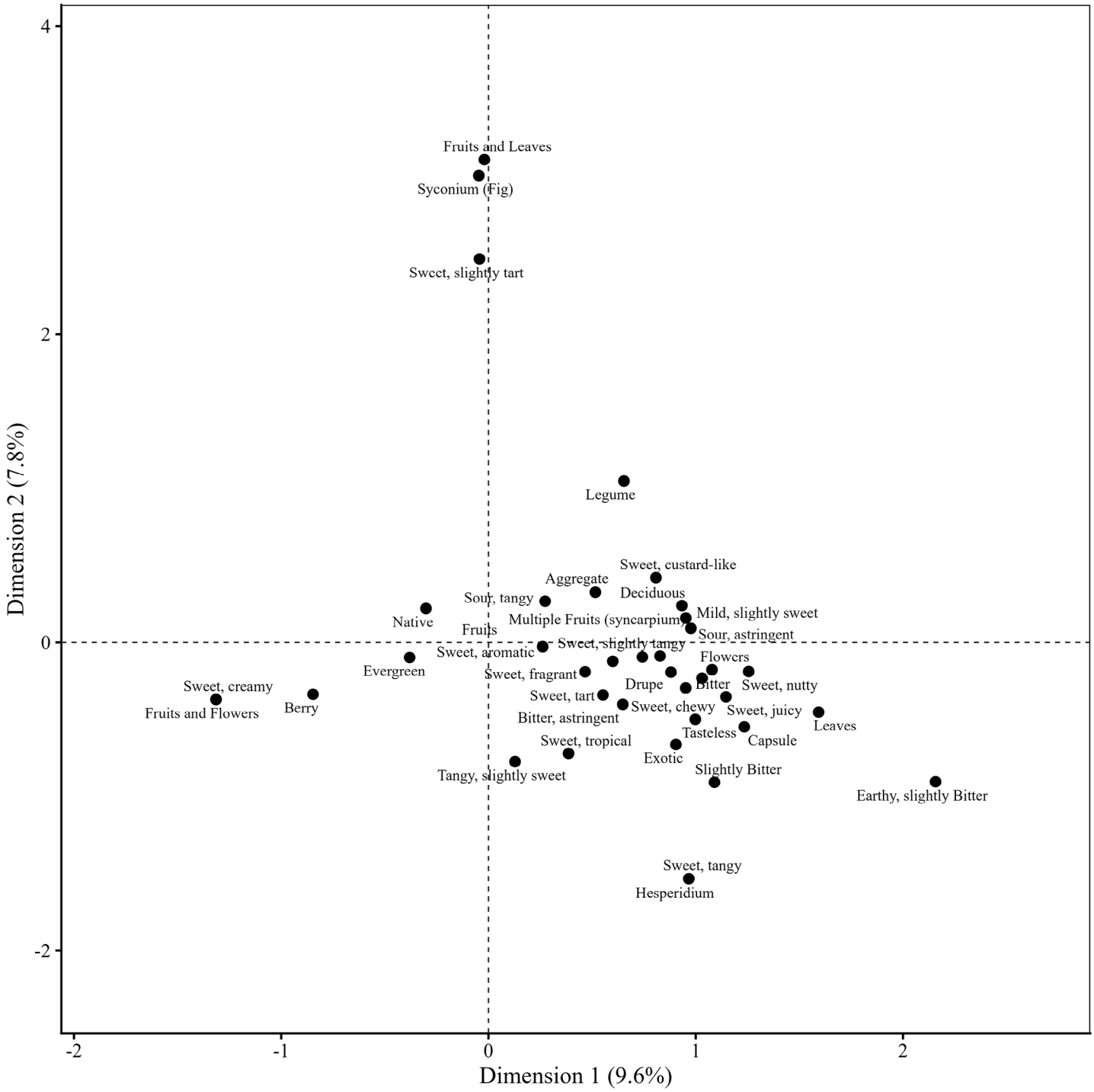


Figure 7. Multiple Correspondence Analysis (MCA) of categorical characteristics of the documented food-plant taxa/entries associated with feeding activity of *Pteropus medius* and *Cynopterus sphinx* in Kamrup District, Assam. The analysis included growth form, fruit type, taste, plant parts associated with feeding, and plant origin. Dimension 1 explained 9.6% of the total inertia, while Dimension 2 explained 7.8%. Together, the two dimensions represented 17.4% of the total inertia. The plot provides an exploratory representation of associations among the recorded plant characteristics.

Dimension 1 accounted for 9.6% of the total inertia, while Dimension 2 accounted for 7.8%. Together, the two dimensions represented 17.4% of the total inertia.

Discussion

The present study documented a diverse assemblage of food plants associated with pteropodid bat feeding in Kamrup District, Assam, comprising 76 food-plant taxa/entries representing 42 genera and 25 families. The documented assemblage encompasses plant resources associated with *Pteropus medius* and *Cynopterus sphinx* in the study area. Its composition provides a baseline for examining the botanical diversity of food plants associated with these bats and their potential ecological relationships with the surrounding vegetation.

Musaceae contributed 24 entries corresponding to the locally recognized *Musa* spp. cultivars. Among the non-*Musa* botanical entries, Moraceae was the most

represented family, while *Ficus* was the most diverse non-*Musa* genus, with six documented entries: *Ficus benghalensis*, *F. racemosa*, *F. hispida*, *F. religiosa*, *F. retusa*, and *F. curtipes*. The representation of *Ficus* is consistent with previous studies documenting fig species among the food plants of fruit bats (Harrison 2005; Sudhakaran and Doss 2012; Krishnarathi and Isaac 2016; Ashwin and Jayakumar 2019; Dihora and Dodia 2023; Singh *et al.* 2024; Kumar and Elangovan 2025). Similarly, Tiwari *et al.* (2019) reported Moraceae among the important plant families consumed by *Pteropus giganteus* in Kathmandu Valley, Nepal. The representation of several *Ficus* species in Kamrup may be ecologically relevant because fig species can provide food resources at different times of the year. Extended or asynchronous fruiting has been documented in *Ficus* and may contribute to its importance for frugivorous animals in tropical ecosystems (Harrison 2005; Coelho *et al.* 2014). Several *Ficus* species recorded in the present study also had year-round or extended flowering and/or fruiting periods according to the phenological information compiled for this study. Similar temporal availability of fig resources has been reported in previous studies of fruit bats (Sudhakaran and Doss 2012; Krishnarathi and Isaac 2016; Ashwin and Jayakumar 2019). Nevertheless, the phenological information compiled here does not establish the extent to which the availability of these plants influenced feeding activity in Kamrup.

Native plants formed a major component of the documented food-plant assemblage, consistent with previous studies reporting the use of indigenous plant resources by Old World fruit bats (Fujita and Tuttle 1991; Hodgkison *et al.* 2003; Sudhakaran and Doss 2012; Aung and Htay 2019; Aziz *et al.* 2021). Several native plants recorded in the present study, including *Syzygium cumini*, *Caryota urens*, and *Dillenia indica*, have also been reported as food resources or ecologically relevant plants for frugivorous bats. Exotic plants, including *Mangifera indica*, *Carica papaya*, and *Psidium guajava*, were also represented. These records demonstrate that the documented food-plant assemblage included plants of both native and introduced origins, although the relative importance of these categories to bat feeding cannot be determined without information on their availability and rates of use.

The documented feeding records were predominantly associated with fruits, although flowers and leaves were also represented. This pattern is consistent with the predominantly frugivorous feeding ecology of pteropodid bats (Kunz *et al.* 2011; Aziz *et al.* 2021). Fruits can provide carbohydrates and water, while flowers and leaves may contribute additional nutrients. Research on *C. sphinx* has documented differences in the nutritional composition of fruits and leaves, highlighting the potential dietary contribution of both plant parts (Ruby *et al.* 2000). Other studies have also recorded the consumption of flowers, nectar, pollen, and leaves among Old World fruit bats (Kunz *et al.* 2011; Aziz *et al.* 2021). Thus, the occurrence of different plant parts in the Kamrup records indicates that the documented food-plant assemblage extended beyond fruits alone. However, the nutritional composition of the recorded plants and the quantities of individual plant parts consumed were not measured in the present study.

Berry-type fruits were the most frequently represented fruit category, followed by drupes. These fruit types are also prominent in studies of tropical fruit resources used by frugivorous animals. Bollen *et al.* (2004) found that berries and drupes constituted a large proportion of the fruit species examined in a Malagasy littoral forest. Their study also reported that the fruit bat *Pteropus rufus* used soft, juicy pulp more frequently than other pulp types. Soft pulp may provide accessible food and water. In Kamrup, the frequencies of fruit categories represent the composition of the documented food-plant records rather than measured feeding preferences. Because fruit availability, pulp characteristics, nutrient composition, and feeding rates were not quantified, the predominance of berry-type fruits cannot be attributed conclusively to their physical or nutritional properties or to active selection by either bat species.

The taste characteristics of the documented food plants were largely represented by sweet-associated categories, with "sweet, creamy" being the most common. This pattern is broadly consistent with previous research indicating that fruit bats exploit sugar-rich fruits and may use sensory cues during food selection (Marshall 1983; Long and Racey 2007; Aziz *et al.* 2017). Research on *C. sphinx* has also examined the role of sensory cues in locating and selecting fruits (Acharya *et al.* 1998). The occurrence of bitter, sour, and astringent categories in the present records indicates that the documented food plants encompassed a range of reported taste characteristics. However, these categories describe the recorded characteristics of the food plants and do not establish that taste directly determined food selection by the bats.

Evergreen plants accounted for a high proportion of the documented food-plant assemblage. Evergreen vegetation may retain foliage throughout the year, but this does not necessarily mean that its fruits or flowers are continuously available. The inclusion of both evergreen and deciduous plants indicates that the documented food plants differed in their broad vegetation characteristics and potential seasonal patterns. However, the availability of individual food resources was not monitored systematically, so the extent to which these characteristics affected feeding activity or seasonal resource use in Kamrup remains uncertain.

The statistical analyses revealed an association between plant origin and the plant parts associated with feeding, indicating that native and exotic plants were represented differently across the recorded feeding-part categories. This relationship may reflect differences in the botanical characteristics of the plants represented in the dataset. In contrast, plant origin was not significantly associated

with fruit type or the broad flowering/fruiting categories examined. These results suggest that the relationship between plant origin and the recorded characteristics varied among the categories analysed. Seasonal resource pulses, such as episodes of mass flowering or fruiting, may also influence the availability of particular food plants. However, these events were not quantified in the present study, and their contribution to the observed statistical patterns could not be evaluated.

Both wild and cultivated plants contributed to the documented food-plant assemblage, with cultivated plants accounting for a larger proportion of recorded entries (64.5%) than wild plants (35.5%). This pattern suggests that plants growing in human-managed environments may form an important component of the food resources associated with fruit-bat feeding in the study area. The presence of cultivated fruit plants alongside native and wild vegetation may reflect the range of food resources available within the landscape, potentially allowing bats to exploit resources across different vegetation settings. Tiwari *et al.* (2019) also documented a diverse assemblage of food plants in the diet of *Pteropus giganteus* in Kathmandu Valley, Nepal, providing a regional comparison for the diversity of plant resources used by Old World fruit bats. However, the present proportions represent the composition of the documented food-plant assemblage rather than the quantity of food consumed. Cultivated plants may have been represented more frequently because of their local abundance, accessibility, fruiting patterns, or other characteristics, but these possibilities could not be evaluated because food-plant availability and feeding rates were not systematically measured.

Potential differences in food-resource use by *Cynopterus sphinx* and *Pteropus medius* may be related to their morphology, foraging behaviour, and use of the surrounding vegetation. Campbell *et al.* (2007) demonstrated that body size, cranial and dental morphology, and habitat associations were related to ecological differences among Malaysian *Cynopterus* species. Although these findings cannot be directly extrapolated to comparisons between *C. sphinx* and *P. medius*, they suggest that morphological and ecological traits may contribute to differences in how fruit bats access and use food resources. Differences in body size, feeding structures, foraging locations, and fruit-handling behaviour may influence the plants accessed by bats and the locations where feeding remains accumulate. Elangovan *et al.* (1999) documented fruit removal and transport to feeding roosts by *C. sphinx*, illustrating how feeding behaviour may influence the distribution of feeding evidence. Similarly, Roy *et al.* (2024) documented the use of multiple tree species, including *Ficus*, by *P. medius* in urban Kolkata and found that tree-cover area influenced the number of bats recorded at foraging sites. These findings provide ecological context for interpreting the diversity of plant genera, fruit types, and plant origins documented in Kamrup, where both wild and cultivated plants were represented. Differences in foraging behaviour, access to food plants, and resource distribution could potentially contribute to variation in resource use between the two bat species. However, because the food-plant records in the present study could not consistently be assigned to individual bat species and food-plant availability was not systematically assessed, the study cannot establish whether *C. sphinx* and *P. medius* differed in their use of particular plants or whether dietary resource partitioning occurred. Thus, resource partitioning remains a plausible hypothesis rather than a demonstrated pattern. Direct, species-specific feeding observations, combined with seasonal assessments of food-plant availability, would be needed to investigate this possibility.

The multiple correspondence analysis (MCA) revealed associations among growth form, fruit type, taste, plant parts associated with feeding, and plant origin. Native and evergreen plants were positioned closer to berry-type fruits and fruits-and-flowers feeding, whereas exotic and deciduous plants occurred in different combinations of fruit, feeding-part, and taste categories. These patterns describe how the recorded botanical characteristics were distributed within the documented food-plant assemblage. However, the ordination represents associations among categorical variables and does not establish causal relationships, actual feeding preferences, or species-specific resource selection.

The documented assemblage also has conservation relevance because pteropodid bats contribute to seed dispersal and pollination, supporting plant regeneration and other ecosystem processes (Fujita and Tuttle 1991; McConkey and Drake 2015). The occurrence of native food plants such as *Dillenia indica*, *Caryota urens*, *Syzygium cumini*, and several *Ficus* species highlights the value of retaining diverse native vegetation within the study landscape. Cultivated and introduced plants were also represented, suggesting that human-managed vegetation formed part of the recorded food-plant assemblage. Nevertheless, documenting a plant as a food resource does not quantify its contribution to seed dispersal, pollination, or plant regeneration in Kamrup.

The conservation status of the documented food plants further provides context for understanding the botanical resources represented in the study. Several plants lacked a formal IUCN assessment, indicating that their global conservation status remains unassessed in the consulted records. Maintaining native fruit- and flower-producing vegetation, including mature trees that provide food resources at different times of the year, may help retain a diverse resource base for pteropodid bats. The conservation of food-producing vegetation can complement the protection of bat roosts and other habitat features, although the present study did not directly evaluate the conservation outcomes associated with individual food plants.

The present study has several methodological limitations. The food-plant records were derived primarily from indirect feeding evidence rather than direct

observation of individual bats feeding or faecal analysis. The findings should therefore be interpreted as an inventory and characterization of documented food plants rather than a quantitative assessment of diet. Species-specific dietary differences, feeding preferences, and resource partitioning between *P. medius* and *C. sphinx* could not be evaluated. The surveyed locations were selected to provide broad spatial coverage rather than to compare food-plant composition among formally defined habitat categories. Because food-plant records were not linked consistently to individual sampling sites, comparisons among different landscape settings were not possible. In addition, comparative confirmation using a dedicated reference collection of known plant material was not available for the documented records. Rainfall, temperature, and other environmental variables were not measured concurrently with the feeding-plant observations; their effects on plant phenology and seasonal patterns of food-plant use could therefore not be assessed.

Despite these limitations, the documented records provide a baseline inventory of food plants associated with the two pteropodid species occurring in Kamrup District.

Future research should integrate species-specific feeding observations with site-linked food-plant records, seasonal monitoring, and assessments of plant-resource availability. Identifying the bat species associated with each feeding event or feeding remain would allow differences in food-plant use and potential dietary partitioning between *P. medius* and *C. sphinx* to be investigated. Long-term monitoring of major bat roosts and surrounding vegetation could also help document changes in roost condition, disturbance, local conservation pressures, and food-resource availability. Maintaining diverse native vegetation, particularly fruit- and flower-producing plants, may help retain food resources within the landscape. Overall, this study provides a botanical baseline for future investigations of bat–plant interactions and for conservation planning concerning pteropodid bats and their associated plant resources in Kamrup District, Assam.

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Declaration of Artificial Intelligence use

During the preparation of this manuscript, Google Gemini AI was used for preliminary translation, language editing, suggestions regarding style and clarity, and grammar checking. The authors independently reviewed and verified all AI-assisted language suggestions and take full responsibility for the scientific content, data, analyses, interpretations, and final version of the manuscript.

Author contributions

Anindita Deka conceptualized the study, conducted field surveys, collected and analysed the data, and wrote the manuscript. Dr. Malabika Kakati Saikia supervised the research, provided critical revisions, and offered guidance throughout the research process. Prof. Prasanta Kumar Saikia reviewed the manuscript and provided scientific guidance.

Supplementary data

SD1. Geographic coordinates of the 50 sampling locations surveyed in Kamrup District, Assam, India, during the study period (Excel spreadsheet).

SD2. Detailed information on the documented food-plant taxa/entries, including family, genus, species, local cultivar/vernacular name, common name, plant parts associated with feeding, fruit type, flowering/fruiting period, IUCN conservation status, taste, wild/cultivated, growth form and origin (Excel spreadsheet).

Figure S1. *Pteropus medius* perched on the food plant *Ficus racemosa* in Kamrup District, Assam, India. Photograph by Anindita Deka.

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